

# PHOSPHINE

CASRN: 7803-51-2



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## Human Health Effects:

### Evidence for Carcinogenicity:

Cancer Classification: Group D Not Classifiable as to Human Carcinogenicity

[USEPA Office of Pesticide Programs, Health Effects Division, Science Information Management Branch: "Chemicals Evaluated for Carcinogenic Potential" (April 2006)] \*\*QC REVIEWED\*\*

CLASSIFICATION: D; not classifiable as to human carcinogenicity. BASIS FOR CLASSIFICATION: Based on inadequate data in animals and no tumor data in humans. While phosphine has not been associated with cancer in humans, there is some evidence of chromosomal damage (transient chromatid deletions, gaps and breaks, persistent chromosomal translocations). A relationship between these genetic effects and the development of cancer in humans is sometimes postulated. HUMAN CARCINOGENICITY DATA: None. ANIMAL CARCINOGENICITY DATA: Inadequate.

[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS). Summary on Phosphine (7803-

51-2), Available from, as of March 15, 2000: <http://www.epa.gov/iris/> \*\*PEER REVIEWED\*\*

## Human Toxicity Excerpts:

/HUMAN EXPOSURE STUDIES/ Three ppm safe for long term exposure, 500 ppm lethal in 30 min. 1000 ppm lethal after few breaths (for man). In **phosphine** inhalation, survival for 4 days is ordinarily followed by recovery....

[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982., p. 458] \*\*PEER REVIEWED\*\*

/SIGNS AND SYMPTOMS/ **Phosphine** differs from arsine in that red blood cell hemolysis does not occur. When low concentrations are inhaled, headaches, dizziness, tremors, general fatigue, GI distress, and burning substernal pain may result. Toxic exposures to **phosphine** have been documented as a result of grain fumigation, attempted suicide, and ferrosilicon decomposition. A productive cough with fluorescent green sputum, acute dyspnea, and pulmonary edema may develop. Death may be preceded by tonic convulsions, which may ensue after apparent recovery ...

[Bingham, E.; Cohrssen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. V3 472] \*\*PEER REVIEWED\*\*

/SIGNS AND SYMPTOMS/ One fatally-poisoned human experienced nausea, vomiting, diarrhea, great thirst, sensation of pressure in the chest, back pains, dyspnea, chills, stupor and fainting with marked pulmonary edema. Some of the above signs are reminiscent of acute phosphorus poisoning except that the distressing local injury of the latter is absent. Chronic **phosphine** poisoning is said to resemble chronic phosphorus poisoning.

[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984., p. II-119] \*\*PEER REVIEWED\*\*

/SIGNS AND SYMPTOMS/ In acute poisoning, the pupils are said to be usually widely dilated.

[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986., p. 733] \*\*PEER REVIEWED\*\*

/SIGNS AND SYMPTOMS/ Poisoning by **phosphine** gas is either on an acute or subacute level. Symptoms,

dependent on dosage, are rapid in onset and initially characterized by respiratory, cardiac, circulatory, and cerebral difficulties with extreme gastrointestinal irritation followed later by renal and hepatic toxicity. At high initial exposure death will occur usually within the first 48 hr.

[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988., p. 527] \*\*PEER REVIEWED\*\*

/SIGNS AND SYMPTOMS/ ...Death may occur after 1/2 to 1 hr of exposure at concentrations of 400 to 600 ppm. Serious effects may be produced by exposure to 5 to 10 ppm for several hours... .

[Bingham, E.; Cohrssen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. V3 472] \*\*PEER REVIEWED\*\*

/SIGNS AND SYMPTOMS/ The respiratory tract is a major target for **phosphine** poisoning. The initial symptoms include cough, sore throat, tightness in the chest, retrosternal pain, dyspnea, followed by persistent coughing, pulmonary edema and respiratory distress syndrome which may induce mortality. In a study of 59 cases of **phosphine** poisoning, 26 patients died mainly due to respiratory disorders. The commonest finding at autopsy was congestion of the lungs with marked edema.

[IPCS; Poisons Information Monograph 865: Phosphine. (October 1997). Available from, as of October 24, 2006: <http://www.inchem.org/documents/pims/chemical/pim865.htm> \*\*PEER REVIEWED\*\*

/SIGNS AND SYMPTOMS/ The liver may be affected by **phosphine**/phosphide poisoning, but the effects are delayed and rarely cause death. Jaundice may occur 24 hours or more after exposure. In 31 cases of **phosphine** poisoning studied ... , jaundice occurred in 52% of the patients. Liver function tests were abnormal in a further 10 patients. Abnormalities included elevations of transaminases (mainly SGPT) and lactic dehydrogenase (5 patients).

[IPCS; Poisons Information Monograph 865: Phosphine. (October 1997). Available from, as of October 24, 2006: <http://www.inchem.org/documents/pims/chemical/pim865.htm> \*\*PEER REVIEWED\*\*

/CASE REPORTS/ Eight cases of **phosphine** poisoning following ingestion of aluminum phosphide tablets for suicidal attempt are described. The mean age of the patients was 23 years (range 14 to 25). The clinical picture consisted of gastritis, altered sensorium and peripheral vascular failure in all cases, cardiac arrhythmia (3), jaundice

and renal failure (1 each). Six patients died, the mean hospital stay was 19 hr (range 4 to 72). Post-mortem examination was performed on two patients, revealing pulmonary edema, gastrointestinal mucosal congestion, petechial hemorrhages on the surface of liver and brain. Histopathological changes included pulmonary edema, desquamation of the lining epithelium of the bronchioles; vacuolar degeneration of hepatocytes, dilatation and engorgement of hepatic central veins, sinusoids and areas showing nuclear fragmentation. The clinical picture of aluminum phosphide poisoning is described and precaution in the distribution and use of this pesticide recommended. /Aluminum phosphide/

[Misra UK, et al; Hum Toxicol 7 (4): 343-5 (1988)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

/CASE REPORTS/... The wife of the captain and two children, plus 29 of 31 crew members on a grain carrier, became ill after inhaling **phosphine** generated from using aluminum phosphide. The first cases occurred 2 days after the fumigation started. The predominant symptoms were fatigue (86%), nausea (72%), headache (66%), vomiting, cough, and shortness of breath. Abnormal physical findings included paresthesia (59%), jaundice (52%), tremor (31%), ataxia, and diplopia. The younger of the two children, who were 2- and a 4-years old, died. Necropsy findings included focal myocardial infiltration, necrosis, pulmonary edema, and widespread small vessel injury. The older surviving daughter had ECG changes and echocardiographic changes indicating heart muscle damage accompanied by an increase of skeletal muscle serum creatine phosphokinase. She recovered in 24 hr. Except for nausea, vomiting, and paresthesia, values of parameters from physical, neurological, and clinical pathological evaluation of the mother were normal; she recovered 24 hr after exposure ceased. Concentrations ranged from 30 ppm in the void space near the midship ventilator intake to 0.5 ppm in the living quarters.

[Bingham, E.; Cohrssen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. V3 473] \*\*PEER REVIEWED\*\*

/CASE REPORTS/ One patient with jaundice among 8 patients with **phosphine** poisoning /was/ studied. The patient died because of renal and hepatic failure and ventricular tachycardia. On autopsy, petechial hemorrhages were seen on the surface of the liver and histopathological examination showed vascular degeneration of hepatocytes.

[IPCS; Poisons Information Monograph 865: Phosphine. (October 1997). Available from, as of October 24, 2006: <http://www.inchem.org/documents/pims/chemical/pim865.htm> \*\*PEER REVIEWED\*\*

/CASE REPORTS/ There has been a single case report of purpura ascribed to **phosphine** poisoning. The platelet count was reduced to 60,000/cu mm and red blood cell to  $3.1 \times 10^6$ /cu mm. On recovery, both the platelet and red cell counts increased to 210,000/cu mm and  $4.8 \times 10^6$ /cu mm, respectively.

[IPCS; Poisons Information Monograph 865: Phosphine. (October 1997). Available from, as of October 24, 2006: <http://www.inchem.org/documents/pims/chemical/pim865.htm> \*\*PEER REVIEWED\*\*

/CASE REPORTS/ ...A case report of suspected inhalation exposure to **phosphine** gas in a manufacturing facility which was associated with acute dyspnea, hypotension, bradycardia and other signs of intoxication. These symptoms resolved within several hours after removal from exposure.

[Sudakin DL; Hum Exp Toxicol 24 (1): 27-33 (2005)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

/CASE REPORTS/ ... A 28-year-old forensic specialist investigating a methamphetamine lab was exposed to **phosphine** without respiratory protection at approximately 2.7 ppm for 20-30 minutes. Shortly following exposure she developed dizziness, cough, headache, and diarrhea, although initial medical evaluation within 1-2 hours was unremarkable. Pulmonary examination at 4 and 7 days postexposure revealed bilateral rhonchi. The cough was worse with exertion, and persisted despite beta-agonist and steroid inhaler treatment.

[Burgess JL; J Toxicol Clin Toxicol 39 (2): 165-8 (2001)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

/CASE REPORTS/ A 39-year-old man committed suicide by ingestion of aluminum phosphide ... The victim was discovered 10 days after the ingestion of the pesticide. When aluminum phosphide comes into contact with humidity, it releases large quantities of hydrogen **phosphine** (PH<sub>3</sub>), a very toxic gas. Macroscopic examination during the autopsy revealed a very important asphyxia syndrome with major visceral congestion. Blood, urine, liver, kidney, adrenal, and heart samples were analyzed. **Phosphine** gas was absent in the blood and urine but present in the brain (94 mL/g), the liver (24 mL/g), and the kidneys (41 mL/g). High levels of phosphorus were found in the blood (76.3 mg/L) and liver (8.22 mg/g). Aluminum concentrations were very high in the blood (1.54 mg/L), brain (36 microg/g), and liver (75 microg/g) compared to the usual published values. Microscopic examination revealed congestion of all the organs studied and obvious asphyxia lesions in the pulmonary parenchyma. All these results confirmed a diagnosis of poisoning by aluminum phosphide. This report points out that this type of poisoning is rare and that hydrogen **phosphine** is very toxic. The phosphorus and aluminum concentrations observed and their

distribution in the different viscera are discussed in relation to data in the literature. /Aluminum phosphide/

[Anger F et al; J Anal Toxicol 24 (2): 90-2 (2000)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

/SURVEILLANCE/ To evaluate the health effects of occupational **phosphine** exposure, 22 workers engaged in fumigation of stored grains were subjected to clinical and environmental study. These workers were used to placing aluminum phosphide tablets on the stacks of grains and covering it with a gas-proof plastic cover. The mean age of the workers was 48 years (range 24 to 60) and mean duration of exposure 11.1 years (range 0.5 to 29). After fumigation they reported minor symptoms, which included cough (18.2%), dyspnea (31.8%), tightness around the chest (27.3%), headache (31.8%), giddiness, numbness and lethargy (13.6% each), anorexia and epigastric pain (18.2% each). The abnormal physical signs included bilateral diffuse rhonchi and absent ankle reflex each occurring in one worker. Motor nerve conduction velocity of median and peroneal nerves, and sensory conduction velocity of median and sural nerves were normal. **Phosphine** concentration in the work environment ranged from 0.17 to 2.11 ppm. Occupational **phosphine** exposure in the workers was associated with mild to moderate symptoms, which were transient.

[Misra UK, et al; Toxicol Lett 42 (3): 257-63 (1988)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

/GENOTOXICITY/ A study was made of 24 professional fumigant applicators, nine of whom were exposed only to **phosphine**, 11 to **phosphine** and other pesticides, and four did not use **phosphine** at all. Specimens were collected at least twice during the application season and again 6 weeks to 3 months after the work of the season had been completed. When possible, blood specimens were taken from applicators twice within a 24 hour period during times of frequent fumigant application. One hundred metaphase lymphocytes from each sample were analyzed. No significant intraperson or intersample variations were noted among the samples taken and analyzed. The results indicated these workers to have significantly increased stable chromosome rearrangements, primarily translocations in G-banded lymphocytes. Less stable aberrations included chromatid deletions and gaps but these were significantly increased only during the application season, and not at later time points. During fumigant application, measure exposure to **phosphine** exceeded accepted national standards. Because **phosphine** was also used as a dopant in the microchip industry and generated in waste treatment, careful consideration must be given to the results of continued and increased exposures.

[Garry VF et al; Science 246: 251-5 (1989)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

/GENOTOXICITY/ ...In enclosed space applications where PH<sub>3</sub> ambient air concentrations exceed the permissible exposure limit (PEL) of 0.4 mg/cu m (range 0.4 to 5.8 mg/cu m) for a duration of more than 20 min, increased chromosome aberrations are detectable in human lymphocytes from exposed workers ... Studies using micronucleus assay found no increase in micronucleus frequency in exposed workers where ambient exposures were less than the PEL ... Follow up studies of the same worker population did not show increased chromosome aberrations. During the interim, changes in application practice from manual probe application to more automated methods and non-use of **phosphine** in pesticide applications were noted ...

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1864] \*\*PEER REVIEWED\*\*

### Skin, Eye and Respiratory Irritations:

Irritating to skin, eyes, and respiratory system.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 49-117] \*\*PEER REVIEWED\*\*

### Medical Surveillance:

There are no specific tests for use in diagnosis.

[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994, p. 639] \*\*PEER REVIEWED\*\*

### Populations at Special Risk:

... Children may be especially susceptible to the toxicity of **phosphine** at low levels. This may be related to the greater intake rate in the young because of a higher rate of metabolism.

[Bingham, E.; Cohrssen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. 3:473] \*\*PEER REVIEWED\*\*

## Probable Routes of Human Exposure:

Poisoning from **phosphine** gas has occurred from handling hot phosphoric acid and white phosphorus explosives, from the production of acetylene gas, and in storage areas for metallic shavings of light metals. ... Also evolved if aluminum phosphate contacts moisture during improper storage, and from the use of calcium phosphide in the manufacture of flares in the pyrotechnic industry.

[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983., p. 1681] \*\*PEER REVIEWED\*\*

Occupational exposure involves acetyl cellulose makers, bronze alloy makers, munitions workers, smoke bomb and incendiary makers, pesticide rat poison worker, fertilizer makers, electroluminescent-coating makers, and semiconductor workers. /Phosphorus/

[Weast, R.C. (ed.) Handbook of Chemistry and Physics. 69th ed. Boca Raton, FL: CRC Press Inc., 1988-1989., p. 1053] \*\*PEER REVIEWED\*\*

Occupational exposure to **phosphine** may occur through inhalation with this compound at workplaces where **phosphine** is produced or used. Monitoring data suggest inhalation as the most likely pathway by which the general public is exposed to **phosphine**. (SRC)

\*\*PEER REVIEWED\*\*

While a conservative 8-hour time-weighted average (TWA) of 0.1 ppm was calculated, the overall weight of evidence supports an occupational TWA of 0.3 ppm. In addition, a 15-minute short-term exposure limit (STEL) of 3 ppm was estimated. The MOE analysis does not indicate that fumigation workers are currently being exposed to unacceptable levels of **phosphine**.

[Pepelko B et al; Risk Anal 24 (5): 1201-13 (2004)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)



## Emergency Medical Treatment:

### Emergency Medical Treatment:

#### EMT Copyright Disclaimer:

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The following Overview, \*\*\* **PHOSPHINE** \*\*\*, is relevant for this HSDB record chemical.

#### Life Support:

- o This overview assumes that basic life support measures have been instituted.

#### Clinical Effects:

##### 0.2.1 SUMMARY OF EXPOSURE

##### 0.2.1.1 ACUTE EXPOSURE

- A) USES: **Phosphine** (PH<sub>3</sub>) is a colorless, flammable toxic gas used in the semiconductor industry. It is also used

as a fumigant, polymerization initiator, and as an intermediate for the preparation flame retardants. When pure, it is odorless, but technical grade samples have an unpleasant odor similar to garlic or rotting fish.

**Phosphine** can also be generated in illicit methamphetamine labs, especially production involving red phosphorus, hydriodic acid, and ephedrine or pseudoephedrine. **Phosphine** is produced when red phosphorus is heated in the presence of acids. The vast majority of exposures are inhalational; when used as a fumigant, pellets of aluminum phosphide, calcium phosphide, or zinc phosphide release **phosphine** upon contact with atmospheric water or an organism's stomach acid. **Phosphine** is a gas at room temperature, so ingestion is unlikely. Toxicity from ingestion of aluminum phosphide or zinc phosphide are covered in separate managements.

- B) TOXICOLOGY: **Phosphine** exerts its toxic effects via inhibition of cytochrome oxidase and generation of free radical damage. Injury occurs primarily after inhalation exposure, though toxicity can occur from ingestion or transdermal contamination. **Phosphine** gas may form explosive mixtures with air and self ignite. When **phosphine** burns, a dense white cloud of phosphorus pentoxide, a severe respiratory irritant, is formed. **Phosphine** breaks down in water.
- C) EPIDEMIOLOGY: Human poisoning is uncommon, but occurs worldwide and can be fatal.
- D) WITH POISONING/EXPOSURE
  - 1) MILD TO MODERATE TOXICITY: Exposure to **phosphine** gas may cause nausea and vomiting, abdominal pain,

diarrhea, thirst, chest tightness, dyspnea, cough productive of sputum, jaundice, elevated liver enzymes, muscle pains, dizziness, headache, fatigue, ataxia, paresthesias, irritation of mucous membranes, acute renal failure with proteinuria, and hematopoietic cancers.

- 2) SEVERE TOXICITY: More severe exposures may cause tachycardia and hypotension, metabolic acidosis, ventricular dysrhythmias, seizures, coma, acute lung injury (which may be delayed), and death. Direct contact with phosphine liquid may cause frostbite, but phosphine gas is not known to produce adverse effects on the skin. Phosphine gas produces no known adverse effects on the eyes. Contact with the skin or eyes to phosphine gas does not normally result in systemic toxicity.

#### 0.2.1.2 CHRONIC EXPOSURE

- A) Chronic poisoning, characterized by anemia, bronchitis, gastrointestinal disturbances, and visual, speech, and motor disturbances, may result from continued exposure to very low concentrations.

#### 0.2.3 VITAL SIGNS

##### 0.2.21 CARCINOGENICITY

###### 0.2.21.1 IARC CATEGORY

- A) IARC Carcinogenicity Ratings for CAS7803-51-2  
(International Agency for Research on Cancer, 2015; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2010; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2010a; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2008; IARC Working Group on the Evaluation

of Carcinogenic Risks to Humans, 2007; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2006; IARC, 2004):

1) Not Listed

#### 0.2.21.2 HUMAN OVERVIEW

A) Hematopoietic system cancers have been seen in grain workers and fumigators.

#### 0.2.22 GENOTOXICITY

- A) In some studies, **phosphine** exposure has been associated with a significant increase in the frequency of chromosome aberrations in peripheral blood lymphocytes.
- B) A study of fumigant applicators exposed to **phosphine** alone or together with other pesticides found significantly increased stable chromosome rearrangements (primarily translocations in G- banded lymphocytes).
- C) In rats and mice, **phosphine** was only a weak genotoxic agent causing only simple chromatid or chromosome deletions at near-toxic exposure levels.

### Laboratory:

- A) Monitor vital signs and mental status.
- B) Monitor continuous pulse oximetry.
- C) Institute continuous cardiac monitoring and obtain an ECG.
- D) Monitor serum electrolytes, renal function, and liver enzymes.
- E) Obtain a chest radiograph in patients with respiratory symptoms.
- F) Echocardiogram may be useful to assess left ventricular function in patients with hypotension or pulmonary edema.

## Treatment Overview:

### 0.4.3 INHALATION EXPOSURE

#### A) MANAGEMENT OF MILD TO MODERATE TOXICITY

- 1) For mild to moderate exposures, the mainstay of treatment is removal from phosphine exposure and supportive care. Monitoring of cardiac, hepatic, and renal functions should occur. Fluid and electrolytes should also be measured, and circulatory and respiratory support given as needed for symptoms.

#### B) MANAGEMENT OF SEVERE TOXICITY

- 1) For severe overdoses, removal from phosphine exposure and supportive care are the most important initial measures. Severe metabolic acidosis can be treated with sodium bicarbonate and standard treatment for dysrhythmias may be needed. Respiratory distress with pulmonary edema and/or acute lung injury may be treated with supplementary oxygen and mechanical ventilation. Hypotension can be treated initially with fluids and then pressors (ie, dopamine, norepinephrine).

#### C) DECONTAMINATION

- 1) PREHOSPITAL: Move patient to fresh air as soon as possible.
- 2) HOSPITAL: Administer oxygen. Wash exposed skin and irrigate exposed eyes.

#### D) AIRWAY MANAGEMENT

- 1) Airway management is one of the primary issues with phosphine toxicity and patients may get critically ill quickly; early intubation may be needed. Patients should be moved to fresh air as soon as possible, and treated with supplemental oxygen and assisted

ventilation as needed. Bronchospasm can be treated with B2 agonists and oral or parenteral corticosteroids.

E) ANTIDOTE

- 1) None

F) ENHANCED ELIMINATION

- 1) Dialysis or hemoperfusion are unlikely to be helpful for **phosphine** exposures.

G) PATIENT DISPOSITION

- 1) HOME CRITERIA: There is no data to support home management.
- 2) OBSERVATION CRITERIA: All patients with exposures should be sent to a healthcare facility for observation for at least a period of 6 to 8 hours of observation. Patients may be discharged home if they are asymptomatic or clearly improving and stable for discharge. Patients should be instructed to return immediately if any respiratory symptoms develop, as onset of acute lung injury may be delayed.
- 3) ADMISSION CRITERIA: Patients with worsening or severe symptoms should be admitted to the hospital and, depending on the severity of their symptoms (eg, respiratory distress requiring intubation), may require an ICU bed. Patients can be discharged once they are hemodynamically stable with clear improvement or asymptomatic from their exposure.
- 4) CONSULT CRITERIA: Consult a medical toxicologist or poison center for any patient with suspected **phosphine** exposure. An occupational physician and industrial hygienist should be involved if the exposure is work-related. Other helpful consultants may include critical care physicians and pulmonologists to help

management of the patient's symptoms.

#### H) PITFALLS

- 1) One concern from **phosphine** exposure is that the characteristic odor might be masked by olfactory fatigue at higher concentrations. Patients should be removed from the exposure as the first line treatment. Severe symptoms, such as pulmonary edema, may be delayed for up to 72 hours after exposure.

#### I) TOXICOKINETICS

- 1) Onset of symptoms may range from immediate to within a few hours. Some toxic manifestations, such as abnormalities in liver enzymes or pulmonary edema, may be delayed for up to 1 to 3 days.

#### J) PREDISPOSING CONDITIONS

- 1) Patients at extremes of age or underlying morbidities, such as chronic lung disease, may be more susceptible to **phosphine** exposure.

#### K) DIFFERENTIAL DIAGNOSIS

- 1) Includes other irritant or toxic gases such as chlorine or cyanide gases.

#### 0.4.4 EYE EXPOSURE

- A) Eye exposures can be treated with simple decontamination and removal from the exposure area. Irrigate exposed eyes.

#### 0.4.5 DERMAL EXPOSURE

##### A) OVERVIEW

- 1) Dermal exposures can be treated with simple decontamination and removal from the exposure area. Wash exposed skin.

### Range of Toxicity:

A) TOXICITY: Occupational exposure limits established by various agencies include NIOSH REL of a 10-hour TWA of 0.3 parts per million (ppm) and 15 minute STEL of 1 ppm, OSHA PEL of an 8-hour TWA of 0.3 ppm, ACGIH TLV 8-hour TWA of 0.3 ppm and 15 minute STEL of 1 ppm, and NIOSH has designated 50 ppm as immediately dangerous to life and health. There have been case reports of a physician being symptomatic after exposure to **phosphine** released from the excised stomach of a patient who died from aluminum phosphide poisoning. A forensic specialist, investigating a methamphetamine lab, who was exposed to 2.7 ppm **phosphine** for 20 to 30 minutes without respiratory protection, and subsequently developed dizziness, cough, headache, and diarrhea, and had rhonchi on physical exam. Occupational exposure to **phosphine** at airborne concentrations of 0.17 to 2.11 ppm during aluminum phosphide grain fumigation resulted in the development of cough, dyspnea, chest tightness, headache, giddiness, numbness, lethargy, anorexia, and epigastric pain.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2016; CCIS Volume 169, edition expires Aug, 2016. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2016; CCIS Volume 169, edition expires Aug, 2016.] \*\*PEER REVIEWED\*\*

### Antidote and Emergency Treatment:

Basic treatment: Establish a patent airway (oropharyngeal or nasopharyngeal airway, if needed). Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Monitor for pulmonary edema and treat if necessary ... . Monitor for shock and



treat if necessary ... . Anticipate seizures and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with 0.9% saline (NS) during transport ... . /**Phosphine** and Related Compounds/

[Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3Rd edition, Elsevier Mosby, St. Louis, MO 2005, p. 490] \*\*PEER REVIEWED\*\*

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious, has severe pulmonary edema, or is in severe respiratory distress. Positive-pressure ventilation techniques with a bag valve mask device may be beneficial. Consider drug therapy for pulmonary edema ... . Monitor cardiac rhythm and treat arrhythmias if necessary ... . Start IV administration of D5W /SRP: "To keep open", minimal flow rate/. Use 0.9% saline (NS) or lactated Ringer's (LR) if signs of hypovolemia are present. For hypotension with signs of hypovolemia, administer fluid cautiously. Consider vasopressors if patient is hypotensive with a normal fluid volume. Watch for signs of fluid overload ... . Treat seizures with diazepam or lorazepam ... . Use proparacaine hydrochloride to assist eye irrigation ... . /**Phosphine** and Related Compounds/

[Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3Rd edition, Elsevier Mosby, St. Louis, MO 2005, p. 491] \*\*PEER REVIEWED\*\*

Skin decontamination. Flush contaminating fumigants from the skin and eyes with copious amounts of water or saline for at least 15 minutes. Some fumigants are corrosive to the cornea and may cause blindness. Specialized medical treatment should be obtained promptly following decontamination. Skin contamination may cause blistering and deep chemical burns. Absorption of some fumigants across the skin may be sufficient to cause systemic poisoning in the absence of fumigant inhalation. For all these reasons, decontamination of eyes and skin must be immediate and thorough. /Fumigants/

[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: <http://www.epa.gov/pesticides/safety/healthcare> p. 162] \*\*PEER REVIEWED\*\*

Physical placement. Remove victims of fumigant inhalation to fresh air immediately. Even though initial symptoms

and signs are mild, keep the victim quiet, in a semi-reclining position. Minimum physical activity limits the likelihood of pulmonary edema. /Fumigants/

[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: <http://www.epa.gov/pesticides/safety/healthcare> p. 162] \*\*PEER REVIEWED\*\*

Respiration. If victim is not breathing, clear the airway of secretions and resuscitate with positive pressure oxygen apparatus. If this is not available, use chest compression to sustain respiration. If victim is pulseless, employ cardiac resuscitation. /Fumigants/

[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: <http://www.epa.gov/pesticides/safety/healthcare> p. 163] \*\*PEER REVIEWED\*\*

Pulmonary edema. If pulmonary edema is evident, there are several measures available to sustain life. Medical judgment must be relied upon, however, in the management of each case. The following procedures are generally recommended: Put the victim in a sitting position with a backrest. Use intermittent and/or continuous positive pressure oxygen to relieve hypoxemia. (Do not give oxygen at greater concentrations or longer periods than necessary, because it may exaggerate the fumigant injury to lung tissue. Monitor arterial pO<sub>2</sub>.) slowly administer furosemide ... to reduce venous load by inducing diuresis. Consult package insert for additional directions and warnings. Some patients may benefit from careful administration of anxiolytic drugs. Whenever possible, such patients should be managed by intensivists in an intensive care center. Limit victim's physical activity for at least 4 weeks. Severe physical weakness usually indicates persistent pulmonary injury. Serial pulmonary function testing may be useful in assessing recovery. /Fumigants/

[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: <http://www.epa.gov/pesticides/safety/healthcare> p. 163] \*\*PEER REVIEWED\*\*

Control convulsions. Seizures are most likely to occur in poisonings by methyl bromide, hydrogen cyanide, acrylonitrile, **phosphine**, and carbon disulfide. /Lorazepam is increasingly being recognized as the drug of choice for status epilepticus, although there are few reports of its use with certain pesticides. One must be prepared to assist ventilation with lorazepam and any other medication used to control seizures. ... Phenobarbital is an additional treatment for seizure control. ... For seizure management, most patients respond well to usual management consisting of benzodiazepines, or phenytoin and phenobarbital./ /Fumigants/

[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: <http://www.epa.gov/pesticides/safety/healthcare> p. 163] \*\*PEER REVIEWED\*\*

Gastrointestinal decontamination. If a fumigant liquid or solid has been ingested less than an hour prior to treatment ... . /Fumigants/

[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: <http://www.epa.gov/pesticides/safety/healthcare> p. 163] \*\*PEER REVIEWED\*\*

Fluid balance should be monitored, and urine sediment should be checked regularly for indications of tubular injury. Measure serum alkaline phosphatase, LDH, ALT, AST, and bilirubin to assess liver injury. /Fumigants/

[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: <http://www.epa.gov/pesticides/safety/healthcare> p. 163] \*\*PEER REVIEWED\*\*

Emergency and supportive measures: 1. Maintain an open airway and assist ventilation if necessary. Administer supplemental oxygen and treat noncardiogenic pulmonary edema if it occurs. 2. Treat seizures and hypotension if they occur. 3. Patients with a history of significant **phosphine** inhalation... should be admitted and observed for 48-72

hours for delayed onset of pulmonary edema. 4. Iv magnesium has been used to treat cardiac arrhythmias otherwise unresponsive to treatment. 5. In severe poisoning, adrenal function may be compromised and iv hydrocortisone should be considered, especially if hypotension does not respond to IV fluids and vasopressors.

[Olson, K.R. (Ed.); Poisoning & Drug Overdose. 5th ed. Lange Medical Books/McGraw-Hill. New York, N.Y. 2007., p. 307] \*\*PEER REVIEWED\*\*

Decontamination: Caregivers are at a low risk for secondary contamination, but off-gassing of **phosphine** may occur if the patient vomits or if gastric lavage fluid is not isolated. ...Enhanced elimination: Dialysis and hemoperfusion have not been shown to be useful in hastening elimination of **phosphine**.

[Olson, K.R. (Ed.); Poisoning & Drug Overdose. 5th ed. Lange Medical Books/McGraw-Hill. New York, N.Y. 2007., p. 308] \*\*PEER REVIEWED\*\*

## Animal Toxicity Studies:

### Evidence for Carcinogenicity:

Cancer Classification: Group D Not Classifiable as to Human Carcinogenicity

[USEPA Office of Pesticide Programs, Health Effects Division, Science Information Management Branch: "Chemicals Evaluated for Carcinogenic Potential" (April 2006)] \*\*QC REVIEWED\*\*

CLASSIFICATION: D; not classifiable as to human carcinogenicity. BASIS FOR CLASSIFICATION: Based on inadequate data in animals and no tumor data in humans. While phosphine has not been associated with cancer in humans, there is some evidence of chromosomal damage (transient chromatid deletions, gaps and breaks, persistent chromosomal translocations). A relationship between these genetic effects and the development of cancer in humans is sometimes postulated. HUMAN CARCINOGENICITY DATA: None. ANIMAL CARCINOGENICITY DATA: Inadequate.

[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS). Summary on Phosphine (7803-

51-2), Available from, as of March 15, 2000: <http://www.epa.gov/iris/> \*\*PEER REVIEWED\*\*

## Non-Human Toxicity Excerpts:

/LABORATORY ANIMALS: Acute Exposure/ ...Rabbits and guinea-pigs /were exposed/ for 4 hr/day to various concentrations of **phosphine**. At 28 mg/cu m (20 ppm), both rabbits and guinea-pigs died during or after the second exposure. At 14 mg/cu m (10 ppm), rabbits survived 7 -14 successive exposures, but at 12 mg/cu m (8.3 ppm), only 4 or 5 exposures. In another study in the series, 2 rabbits that had had five 4-hr exposures to **phosphine** at 7 mg/cu m were accidentally exposed to 20 mg/cu m (14 ppm) on the sixth day. Both rabbits died during this exposure. /It was/ concluded that pretreatment with sub-lethal concentrations of **phosphine** reduced resistance to near-lethal concentrations. At low concentrations (up to 14 mg/cu m), animals displayed no signs until about 1/2 hr before death when they exhibited diminished reactivity, became stuporose with shallow respiration, and died in coma. Occasionally, animals died following exposure, with symptoms of pulmonary edema. At 28 mg/cu m or more, all animals exhibited signs of respiratory irritation and died of pulmonary edema. Pathological examination of the lungs revealed bronchiolitis and atelectasis of the lungs. There was no evidence of hemolysis, but all organs were hyperemic. The liver showed fatty infiltration and there was cloudy swelling of kidney tubular cells. After prolonged exposure, lungs frequently contained a brown pigment that did not stain with Prussian Blue and therefore was not iron-containing.

[WHO; Environ Health Criteria 73: Phosphine and Selected Metal Phosphides p.67 (1988)] \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Acute Exposure/ The effects of a 1.5-month exposure of white rats to **phosphine** at concentrations of 0.05, 0.2, 1.5, and 8 mg/cu m were reported... . There were changes in blood cholinesterase, peroxidase, and catalase activity and in phagocyte behavior. The magnitude of the changes was large, but not generally dose-related.

[WHO; Environ Health Criteria 73: Phosphine and Selected Metal Phosphides p.69 (1988)] \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Acute Exposure/ In a /short term/ study of the effects of **phosphine** on rats by inhalation at 0.1 mg/cu m and 0.05 mg/cu m, /it was/ found a reduction in total plasma protein without a change in the relative proportions of the various fractions, a modest but significant reduction in the glycoprotein A fraction with some

changes in the relative proportions of the sub-fractions, increased plasma bile acids, and a marked increase in seromucoids. Liver glycogen, lipids, and cytochrome oxidase levels were reduced. Biochemical changes were similar to those in a control group treated with hydrogen fluoride at a known toxic level.

[WHO; Environ Health Criteria 73: Phosphine and Selected Metal Phosphides p.69 (1988)] \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Acute Exposure/ ...The 4-hour LC50 of **phosphine** for rats /was found/ to be 11 ppm. Signs of exposure were typical of respiratory irritation and included hyperemia of the ears, salivation, lacrimation, face-pawing, and dyspnea. No effects attributable to **phosphine** exposure were found on the lungs, liver, spleen, kidney, testes or ovaries, brain, heart, trachea, hilar lymph node, pancreas, epididymis, esophagus, stomach, duodenum, bone marrow, skin, or eyes.

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-1634 2006.] \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Acute Exposure/ ... /It was/ demonstrated in pregnant Fischer 344 female rats, exposed 6 hr daily, 4 days was the median lethal time at a concn of 9.7 mg/cu m. Concn below 7 ppm showed no lethality.

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1863] \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Acute Exposure/ **Phosphine** was studied in male and female F344 rats and B6C3F1 mice. In a 4-day pilot study, male rats and mice were exposed to 0, 1, 5, and 10 parts per million (ppm) of **phosphine** for 6 hours daily, five animals per group. Immediately after the last exposure, animals were sacrificed, and blood, lung, liver, heart, and kidneys were collected ... All mice exposed to 10 ppm **phosphine** were moribund after the last exposure. Statistically significant decreases in erythrocyte counts, hemoglobin, and hematocrits occurred in mice exposed to 1 and 10 ppm. Mice exposed to 10 ppm of **phosphine** showed significant increases in serum urea nitrogen, alanine aminotransferase, and sorbitol dehydrogenase compared with controls. Moribund mice showed necrotic kidney lesions, hemorrhagic and necrotic liver lesions, and myocardial degeneration ...

[Bingham, E.; Cohrssen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. V3 471] \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Acute Exposure/ Animal experiments have revealed that rabbits exposed to 70 mg **phosphine**/cu m (50 ppm) for 10 minutes do not develop any symptoms but exposure to 140 mg/cu m (/100 ppm/) is fatal in 2.5 to 3 hour, and 700 mg/cu m (500 ppm) is fatal 25 to 30 minutes. Rats survive exposure to 80 and 800 mg/cu m for 4 and 1 hour, respectively. All animals exhibited signs of respiratory irritation and died of pulmonary edema. Pathological examination of the lungs revealed bronchiolitis and atelectasis; there was no evidence of hemolysis but all organs were hyperemic. The liver showed fatty infiltration and there was cloudy swelling of kidney tubular cells. Neurohistological studies in rats revealed widening of the perivascular spaces, vacuolization of the nuclei of ganglion cells, a reduction in the Purkinje cells and a glial reaction.

[IPCS; Poisons Information Monograph 865: Phosphine. (October 1997). Available from, as of October 24, 2006: <http://www.inchem.org/documents/pims/chemical/pim865.htm> \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Acute Exposure/ ... /Rats, rabbits, guinea pigs and cats/ exposed to high concentration of **phosphine** quickly develop lassitude, ataxia, apnea, and cardiovascular collapse resulting in death within one half-hour. At lower concentration (range studied 7.5 to 564 mg/cu m) time to death varied with dose. Concentrations as low as 7 mg/cu m are lethal over a period of 820 hr.

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1862] \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Rats exposed to **phosphine** repeatedly at 4 ppm for 4 hours daily on 9 of 12 days exhibited a slightly reduced weight gain, which returned to normal during the 14-day recovery period. Signs of mild respiratory irritation were observed in these animals. /Investigators/ found that **phosphine** concentrations of 5 ppm could be tolerated by laboratory animals for 2 months of 4-hour daily exposures, but fatalities resulted after 7 similar exposures at 10 ppm.

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-1634 2006.] \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ In mice (both sexes) the Median Lethal Dose after 2 wk exposure is 9 mg/cu m. Conc'n below this level were not lethal.

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego,

California., p. 1863] \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ **Phosphine** was studied in male and female F344 rats and B6C3F1 mice ... In ... /a/ 2-week study ... /animals/ were exposed to 0, 1.25, 2.5, and 5 ppm of **phosphine** for 6 hours daily, 5 days a week ... No mortalities occurred in rats and mice exposed for 2 weeks. No microscopic evidence of treatment-related effects occurred in any tissue of rats and mice exposed to 5 ppm for 2 weeks. The authors concluded that **phosphine** inhalation lacks target organ specificity in rats and mice and lethality is the primary hazard of subchronic PH3 exposure.

[Bingham, E.; Cohrssen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. 3:472] \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ ... No lethality /was reported/ in male and female rats acutely exposed to 10 ppm **phosphine** for 6 hr ... /and/ 3-day exposure to 10 ppm **phosphine** was lethal /to female rats/ ... /It was/ further demonstrated that female rats were more sensitive to the lethal effects of the inhaled gas.

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1863] \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Cats, guinea-pigs and rats /were exposed/ to **phosphine** concentrations of 1.4 and 3.5 mg/cu m (1 and 2.5 ppm) for 4-6 hr/day, 6 days/wk, for a total of more than 800 hr over a 24-wk period without any clinical, laboratory, or pathological evidence of effects. The liver function in the cats, measured by bromosulphthalein (BSP) excretion, was normal. In cats (3), guinea-pigs (3), and rats (10) exposed to **phosphine** at 7 mg/cu m (5 ppm) for 6-8 hr/day, the cats became apathetic, showing anorexia after exposure, but exhibiting thirst. Later, they developed unsteadiness, vomiting, agitation, dyspnea, and apnea, before cardiac arrest after a total of 35.5-45.5 hr of exposure. The hemoglobin concentration and erythrocyte count were reduced by 10-20% compared with initial values, there was proteinuria and delayed BSP excretion. Post-mortem examination revealed congestion of all organs, with edema and focal emphysema and red pigmentation of the lungs. The guinea-pigs exhibited signs that were similar to, but more marked than, those in the cats, and 2 animals had asphyxial convulsions. Blood tests showed no deviations from normal values, but the blood contained a brown coloration that was not due to methemoglobin, since spectroscopy revealed the absorption bands of oxyhemoglobin



only. The guinea-pigs died on the sixth day after 24-32 hr cumulative exposure, and post-mortem examination revealed pulmonary edema and red discoloration and congestion of other organs. The rats died after 27-36 hr cumulative exposure. All exhibited congestion of organs, 3 had pulmonary edema and 7 had proteinuria. A second series of exposures under slightly changed exposure conditions at a different time of year produced qualitatively similar results. In both series, neurohistological studies in rats showed widening of the perivascular spaces, vacuolation of the nuclei of ganglion cells, a reduction in the Purkinje cells, and a glial reaction. Similar, but less marked, changes without glial reaction were seen in the cats and guinea-pigs. There was no control group in these studies, and certain observations in exposed animals were dismissed on the grounds that they had previously been seen in unexposed animals.

[WHO; Environ Health Criteria 73: Phosphine and Selected Metal Phosphides p.68 (1988)] \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Charles River-CD rats to **phosphine** for 4 hr/day, for 12 days, at a concentration of 5.5 mg/cu m (0.163 umol/L). The rate of weight gain was reduced during the exposure period. Although the authors stated that the rate returned to normal during a 14-day post-exposure observation period, their data indicate a uniformly reduced rate of weight gain throughout the exposure and recovery phases. Post-mortem examination of rats, sacrificed both at the end of the exposure period and at the end of the recovery period, revealed no gross or microscopic abnormalities.

[WHO; Environ Health Criteria 73: Phosphine and Selected Metal Phosphides p.69 (1988)] \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ No toxic effects were seen in survival, body weight, hematologic or urine analysis, bone smear data or tumor development of albino rats fed 2 yr on diet with high concn of **phosphine**-releasing phostoxin pellets, a cereal grain fumigant. /dose not given/

[Hackenberg U; Toxicol Appl Pharmacol 23 (1): 147-58 (1972)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ ...No carcinogenic effects /were noted/ in rats chronically exposed to an inhaled dose of 3 ppm **phosphine** after 1 yr.

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1864] \*\*PEER REVIEWED\*\*

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ ... There were no **phosphine**-related effects seen on clinical observations, body weight, food consumption, hematology, clinical chemistry, urinalysis, or ophthalmology. There were no **phosphine**-related macroscopic findings or effect on absolute or relative organ weights. No histomorphologic alterations attributable to **phosphine** exposure were seen.

[Newton PE et al; Inhal Toxicol 11 (8): 693-708 (1999)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

/LABORATORY ANIMALS: Developmental or Reproductive Toxicity/ One study of animal teratogenicity with exposure concn as high as 4.9 ppm during days 6 to 15 of gestation in rats showed neither maternal toxicity nor developmental toxicity.

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1864] \*\*PEER REVIEWED\*\*

/GENOTOXICITY/ The possibility that structurally simple chemicals might have similar genotoxic properties in vivo and in vitro /was tested/. ... /The/ in vitro protocol /was designed/ to mimic to the extent possible, a single in vivo exposure of lymphocytes to fumigants. ... Lymphocytes were treated with different doses of carbon tetrachloride, carbon disulfide, methyl bromide, chloropicrin, and malathion with and without addition of rat liver homogenate for 1/2 hour, washed free of toxicant, and stimulated with phytohemagglutinin. After cultures, the prepared slides were studied for chromosomes aberrations and SCEs. Malathion, methyl bromide, and chloropicrin significantly induced SCEs with S-9. Carbon disulfide alone required S-9 for significant SCE induction. Chromosome aberrations were significantly increased by malathion and methyl bromide. Carbon tetrachloride failed to induce SCEs or chromosome aberrations with or without S-9. We concluded... that the fumigants studied here may be less likely to express genotoxicity in terms of SCEs or chromosome aberrations than ethylene oxide or **phosphine** given a single short-term in vivo exposure.

[Garry VF, et al; Teratogeneis Carcinog Mutagen 10 (1): 21-9 (1990)] \*\*PEER REVIEWED\*\*

/GENOTOXICITY/ The exposure of male F344/N rats and male B63F1-mice to multiple dosing with **phosphine** during an 11-day period to determine the in vivo cytogenetic effects was examined in this study. Exposures were to 1.25, 2.5, or 5 parts per million (ppm) of **phosphine**, 6 hours a day, on 9 days during an 11-day period. **Phosphine** inhalation caused no statistically significant increases in sister chromatid exchange (SCE) or chromosomal

aberrations (CAs) in peripheral blood lymphocytes (PBLs) or micronuclei (MN) in peripheral blood PCEs or binucleated (BN) lymphocytes. All of the chromosomal aberrations observed were either simple chromatid or chromosomal deletions. Cytogenetic results were similar for the rats and mice. The only **phosphine** effect noted in the dominant lethal study was a slight decrease in the number of implants per female in mating interval six, which sampled sperm exposed primarily as spermatocytes. Based on the in vivo exposure of rats and mice, the authors concluded that PH3 is at most a weak genotoxic agent and may sometimes cause slight increases in cytogenetic damage when exposures are near toxic levels.

[Bingham, E.; Cohrssen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. 3:472] \*\*PEER REVIEWED\*\*

/GENOTOXICITY/ In subacute tightly controlled animal studies using purified PH3 mixed with nitrogen, no incr numbers of micronuclei or chromosome aberrations were found in spleen cells cultured from animals exposed to **phosphine** for 6 hr/day for 9 days at conc as high as 7 mg/cu m in ambient air. A single 6 hr 20 mg/cu m study ... showed similar negative results.

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1864] \*\*PEER REVIEWED\*\*

/GENOTOXICITY/ ... Exposure of human lymphocytes to concn of **phosphine** (1.4 to 4.5 ug/L) derived from AIP for 20 mins yielded incr chromosome aberrations after 96 hr of lymphocyte culture, indicating that the expression of genotoxicity of **phosphine** is delayed.

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1864] \*\*PEER REVIEWED\*\*

/GENOTOXICITY/ In a ... mechanistic examination of the genotoxicity of **phosphine** derived from AIP or Mg3P2 in Hepa cells at a nominal concn of 1 mM PH3 ... reactive oxygen species were maximally generated between 0.5 to 1.5 hr, while damage to DNA expressed as 8-hydroxyguanine adducts occurred between 4 and 6 hr ... **Phosphine** or its reaction products derived from AIP can generate DNA damage and ... expression of these effects is delayed probably indirectly and dependent on generation of hydrogen peroxides.

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego,

California., p. 1864] \*\*PEER REVIEWED\*\*

/GENOTOXICITY/ ...Increased micronucleus (MN) induction in bone marrow polychromatic erythrocytes (PCE) was seen following subchronic exposure to PH3 in male mice at 5.0 ppm, and female mice at 2.5 and 5.0 ppm. In rats, MN elevation in bone marrow PCE and pulmonary alveolar macrophages was seen at 1.0 and 4.0 ppm, respectively, following subchronic exposure.

[Bonin AM et al; Toxicol Lett 95 (Suppl 1): 47 (1998)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

/GENOTOXICITY/ The ...mutagenicity of **phosphine** to two strains of Bacillus subtilis (H 17 rec+ and M 45 rec-) were determined. ...The degree of mutagenicity of **phosphine** to both strains of Bacillus subtilis /was correlated with the ability to inhibit/.

[Ogawa T et al; Bull Environ Contam Toxicol 42 (3): 402-8 (1989)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

/OTHER TOXICITY INFORMATION/ /Following/ exposure to **phosphine**, ChR-CD male rats had clinical signs indicative of mild exposure resulting in mild wt loss during a 10 day exposure period followed by normal rate of weight gain during a 14 day recovery period.

[WARITZ RS, BROWN RM; AM IND HYG ASSOC J 36 (6): 452-8 (1975)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

/OTHER TOXICITY INFORMATION/ /Poisoned animals/ exhibit dyspnea, weakness, tremor, convulsions and death with pulmonary edema.

[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984., p. II-119] \*\*PEER REVIEWED\*\*

/OTHER TOXICITY INFORMATION/ Because **phosphine** is an explosive hazard, many of the lab-based studies have been conducted under exposure conditions to eliminate or reduce the possibility of the branched chain oxidation reaction in air. Thus, these studies reflect the effects of **phosphine** in the unoxidized state. Human case and field population studies and some in vitro studies may reflect to a greater or lesser degree the toxicant effects of **phosphine** and its autooxidation products induced by the contaminant diphosphine in the commercial product, and uncontrolled environmental condition including UV light, humidity, temp, and/or ammonia as well.

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1862] \*\*PEER REVIEWED\*\*

## Ecotoxicity Excerpts:

/BIRDS and MAMMALS/ Three turkeys /were exposed/ to **phosphine** at a concentration of 211 mg/cu m and 6 hens at 224 mg/cu m in an acute inhalation study. The turkeys exhibited apathy, restlessness, dyspnea, and tonic-clonic convulsions, and died after 68, 74, and 80 min, respectively. When examined, organs were congested with oxygenated blood. Hens exhibited tonic-clonic convulsions and died after an average of 59 min (range, 50-64 min). Their organs were also congested with oxygenated blood.

[WHO; Environ Health Criteria 73: Phosphine and Selected Metal Phosphides p.59 (1988)] \*\*PEER REVIEWED\*\*

/OTHER TERRESTRIAL SPECIES/ **Phosphine** decreased the respiration of *Rhyzopertha dominica* (lesser grain borer; beetle) adults susceptible to the fumigant but had little effect on that of a strain selected for its resistance to this gas. Inhibition of mitochondrial oxidation by **phosphine** in vitro was similar in both strains.

[Price NR; Insect Biochem 10 (1): 65-71 (1980)] \*\*PEER REVIEWED\*\*

/OTHER TERRESTRIAL SPECIES/ A survey of resistance to **phosphine** was conducted with adults of the lesser grain borer (*Rhyzopertha dominica*), the rust-red flour beetle (*Tribolium castaneum*), and the confused flour beetle (*T. confusum*). Resistance was detected in 3 of 112 strains of *Rhyzopertha dominica*, 11 of 90 strains of *Tribolium castaneum*, and 2 of 7 strains of *T. confusum*.

[Attia FI, Greening HG; Gen Appl Entomol 13: 93-7 (1981)] \*\*PEER REVIEWED\*\*

## Non-Human Toxicity Values:

LC50 Rat (male) inhalation 11 ppm/4 hr

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1863] \*\*PEER REVIEWED\*\*

LC50 Rat, CHR-CD male, Inhalation 0.44 umol/L/4 hr.

[WARITZ RS, BROWN RM; AM IND HYG ASSOC J 36 (6): 452-8 (1975)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

LC50 Mice (male) inhalation 26.5 ppm/4 hr

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1863] \*\*PEER REVIEWED\*\*

## Ongoing Test Status:

The following link will take the user to the National Toxicology Program (NTP) Test Agent Search Results page, which tabulates all of the "Standard Toxicology & Carcinogenesis Studies", "Developmental Studies", and "Genetic Toxicity Studies" performed with this chemical. Clicking on the "Testing Status" link will take the user to the status (i.e., in review, in progress, in preparation, on test, completed, etc.) and results of all the studies that the NTP has done on this chemical. [[http://ntp-](http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchresults&searchterm=7803-51-2)

[apps.niehs.nih.gov/ntp\\_tox/index.cfm?fuseaction=ntpsearch.searchresults&searchterm=7803-51-2](http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchresults&searchterm=7803-51-2)

[Available from: [http://ntp-](http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchresults&searchterm=7803-51-2)

[apps.niehs.nih.gov/ntp\\_tox/index.cfm?fuseaction=ntpsearch.searchresults&searchterm=7803-51-2](http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchresults&searchterm=7803-51-2) \*\*QC

REVIEWED\*\*

## Metabolism/ Pharmacokinetics:

### Metabolism/ Metabolites:

Metal phosphides are hydrolysed to **phosphine** and the corresponding metal cation. In rats, **phosphine** that is not excreted in the expired air is oxidized and appears in the urine, chiefly as hypophosphite and phosphite.

[WHO; Environ Health Criteria 73: Phosphine and Selected Metal Phosphides p.50 (1988)] \*\*PEER REVIEWED\*\*

## Absorption, Distribution & Excretion:

Inhaled **phosphine** is generally considered to be rapidly absorbed through the lungs.

[IPCS; Poisons Information Monograph 865: Phosphine. (October 1997). Available from, as of October 24, 2006:

<http://www.inchem.org/documents/pims/chemical/pim865.htm> \*\*PEER REVIEWED\*\*

Studies with (32)P-**phosphine** showed that residues did remain in grain after proper ventilation ... Residues were ... incorporated into the tissues of mice that ate fumigated flour. The excreta were highly radioactive at first, but activity disappeared about 3 weeks after feeding was stopped.

[Hayes, Wayland J., Jr. Pesticides Studied in Man. Baltimore/London: Williams and Wilkins, 1982., p. 134] \*\*PEER REVIEWED\*\*

Uptake of **phosphine** by insects is rapid in the presence of oxygen, but little absorption occurs in low or zero oxygen atmospheres, and the insecticide potential is thus reduced. Over 100 mg **phosphine**/kg body weight may be absorbed by insects at high dosage rates, and some insects continue to absorb **phosphine** for long periods, even after knock down. **Phosphine** taken up by insects is not removed by ventilation of volatile **phosphine** derivatives or **phosphine** itself but is apparently excreted slowly. Most of the (32)P, derived from (32)PH<sub>3</sub>, taken up by insects is found in the soluble fraction of the cells; in deproteinized tissue extracts, the radiolabel is present mainly as hypophosphite and orthophosphate.

[WHO; Environ Health Criteria 73: Phosphine and Selected Metal Phosphides p.48 (1988)] \*\*PEER REVIEWED\*\*

## Mechanism of Action:

Lipophilic phosphines form strong complexes with oxidized and reduced cytochromes causing complex difference spectra and shifts in the ESR spectra. These can be displaced by other ligands such as metyrapone (oxidized P450-**phosphine**) or CO (reduced P450-**phosphine**). /Phosphines/

[The Chemical Society. Foreign Compound Metabolism in Mammals. Volume 4: A Review of the Literature Published during 1974 and 1975. London: The Chemical Society, 1977., p. 292] \*\*PEER REVIEWED\*\*

**PHOSPHINE** INHIBITED RESP CHAIN OF RAT LIVER MITOCHONDRIA, USING SUCCINATE OR PYRUVATE PLUS MALATE AS SUBSTRATE, BY INHIBITING RESP RELEASED BY AMP, CA-2+ OR DINITROPHENOL.

[NAKAKITA H ET AL; BIOCHEM (TOKYO) 69 (3): 589-93 (1971)] \*\*PEER REVIEWED\*\*

**PHOSPHINE** INHIBITS STATE 3 & STATE 4 RESP ACTION BY ITS DIRECT INHIBITION OF ELECTRON TRANSPORT DUE TO INTERACTION OF CYTOCHROME OXIDASE IN RESP CHAIN OF MITOCHONDRIA FROM MOUSE LIVER, HOUSEFLY, & GRANARY WEEVIL.

[CHEFURKA W ET AL; PESTIC BIOCHEM PHYSIOL 6 (1): 65-81 (1976)] \*\*PEER REVIEWED\*\*

The inhibitory effects of **phosphine** on cytochrome c oxidase and catalase were investigated in *Rhyzopertha dominica*, *Oryzaephilus surinamensis*, and *Cryptolestes ferrugineus*. Cytochrome c oxidase is inhibited by treatment of insect homogenates in vitro. Catalase is inhibited in susceptible insects poisoned with **phosphine** in vivo. Resistant insects absorb less **phosphine** than susceptible ones.

[Price NR, Dance SJ; Comp Biochem Physiol 76C (2): 277-81 (1983)] \*\*PEER REVIEWED\*\*

**Phosphine** inhibited catalase activity in the lesser grain boring beetle. Base levels of catalase were higher in a strain of the insect selected for resistance to **phosphine** and in a field strain found to be highly resistant. Uptake of **phosphine** and inhibition of catalase were lower in resistant strains than in a susceptible strain.

[Price, NR et al; Comp Biochem Physiol 73C (2): 411-13 (1982)] \*\*PEER REVIEWED\*\*

The spectral changes in hemoglobin, myoglobin, catalase, and peroxidase were studied as part of an investigation of the biochemical mode of action of **phosphine**. Slow deoxygenation of both the oxygen carrier proteins, hemoglobin, and myoglobin resulted from treatment with **phosphine** while there was no significant spectral change in either catalase or peroxidase and there was no direct inhibition of catalase activity. **Phosphine** appeared to have higher affinity for oxygen than hemoglobin or myoglobin. The toxic action of **phosphine** based on its reducing and deoxygenating properties is suggested.



[Chaudhry MQ, Price NR; Pestic Biochem Physiol 36 (1): 14-21 (1990)] \*\*PEER REVIEWED\*\*

...Male Wistar rats were treated ip with /**phosphine**/ (PH(3)) at 2 mg/kg. Thirty min later the brain, liver, and lung were analyzed for glutathione (GSH) levels and lipid peroxidation (as malondialdehyde and 4-hydroxyalkenals) and brain and lung for 8-hydroxydeoxyguanosine (8-OH-dGuo) in DNA. PH(3) caused a significant decrease in GSH concentration and elevation in lipid peroxidation in brain (36-42%), lung (32-38%) and liver (19-25%) and significant increase of 8-OH-dGuo in DNA of brain (70%) and liver (39%).

[Hsu C et al; Free Radic Biol Med 28 (4): 636-642 (2000)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

... In vitro studies, both animal and insect, have shown that the respiratory enzyme, cytochrome c oxidase, may be the specific site of action. On the other hand, in vivo treatment of insects with lethal dose levels of **phosphine** showed no more than 50% inhibition of the enzyme ... /and/ this level of respiratory enzyme inhibition was sufficient to generate superoxide anions ... /It was/ suggested that the toxicity of **phosphine** was due to free radical damage.

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1863] \*\*PEER REVIEWED\*\*

... **Phosphine**-induced hemoglobin denaturation, oxidation to methemoglobin, and formation of a peculiar pigmented form of hemoglobin "Verdichromogen" /was described/. Studies of purified hemoglobin ... showed that with increase duration of exposure, **phosphine** in concn as low as 0.11 uM gradually resulted in the formation of hemichrome pigment. In intact red blood cells ... formation of Heinz bodies (hemoglobin protein aggregates) /was noted/ at PH3 concn as low as 2 ug/mL. The toxicant effects both in intact cells and in purified hemoglobin were abolished by incubation in a reduced oxygen atmosphere, indicating an oxygen requirement for **phosphine** hemoglobin toxicity.

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1863] \*\*PEER REVIEWED\*\*

Studies ... in animals showed that the /**phosphine**/ gas inhibited myeloperoxidase enzyme at concn of 8 mg/cu m ... A 50% reduction in myeloperoxidase activity in neutrophils from exposed workers compared to control subjects /was noted/. Ambient air monitoring data obtained at the time varied from 0.4 to 5.8 mg/cu m ... In 45 patients recovering from **phosphine** poisoning, serial studies of serum levels of superoxide dismutase (SOD), malondialdehyde (MDA),

and catalase were performed. Incr levels of SOD and MDA were found in nonsurvivors while catalase was inhibited. Remarkably similar findings (ie, decr peroxidase and catalase and incr superoxide dismutase) were reported ... in insects ... Taken together ... **phosphine** intoxication can lead to accumulation of cellular peroxides.

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1864] \*\*PEER REVIEWED\*\*

... The oxidation of **phosphine** can lead to formation of reactive phosphorylating species ... Significant inhibition of cholinesterase was detected in animals. Occupational studies of grain fumigant applicators and in vitro studies in human red blood cells demonstrate that significant **phosphine**-induced inhibition of red cell cholinesterase occurs at concn exceeding 10 ug/mL.

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1864] \*\*PEER REVIEWED\*\*

Much of the work regarding **phosphine** as a metabolic poison centers on the concept that reactivity of **phosphine** as a nucleophile, and/or the electrophilic character of the intermediates arising from oxidation, could lead to derivatization of critical biomolecules. Certain critical biologic endpoints including the cytochromes and cytochrome oxidase system, hemoglobin, peroxidases and lipid peroxidation, catalase, cholinesterase, and DNA ... **Phosphine** is a toxicant gas with strong reducing properties capable of chemical and biologic oxidant effects. The signature threshold for lethality over a narrow dose range and slow evolution of mortality at lower doses indicates that the chemical induces a cumulative biologic oxidant cascade involving progressive alteration of ... critical biologic endpoints ...

[Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1863] \*\*PEER REVIEWED\*\*

## Environmental Fate & Exposure:

### Environmental Fate/Exposure Summary:

**Phosphine's** production as a by-product from the storage of ferrous alloys and phosphide hydrolysis may result in its release to the environment through various waste streams. **Phosphine's** use as a fumigant will result in its direct release to the environment. If released to air, a vapor pressure of 29,300 mm Hg at 25 deg C indicates **phosphine** will exist solely as a gas in the atmosphere. Gas-phase **phosphine** will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; and has a reported atmospheric half-life of less than 1 day.

**Phosphine** does not contain chromophores that absorb at wavelengths >290 nm and therefore is not expected to be susceptible to direct photolysis by sunlight. **Phosphine** is a gas and therefore is expected to volatilize from water and moist and dry soil surfaces. Studies have shown that sub-surface **phosphine** may bind to soil; volatilization is expected to be the most important fate process since **phosphine** is a gas. Occupational exposure to **phosphine** may occur through inhalation of this compound at workplaces where **phosphine** is produced or used. Monitoring data suggest inhalation as the most likely pathway by which the general public is exposed to **phosphine**. (SRC)

**\*\*PEER REVIEWED\*\***

### Probable Routes of Human Exposure:

Poisoning from **phosphine** gas has occurred from handling hot phosphoric acid and white phosphorus explosives, from the production of acetylene gas, and in storage areas for metallic shavings of light metals. ... Also evolved if aluminum phosphate contacts moisture during improper storage, and from the use of calcium phosphide in the manufacture of flares in the pyrotechnic industry.

[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983., p. 1681] **\*\*PEER REVIEWED\*\***

Occupational exposure involves acetyl cellulose makers, bronze alloy makers, munitions workers, smoke bomb and incendiary makers, pesticide rat poison worker, fertilizer makers, electroluminescent-coating makers, and semiconductor workers. /Phosphorus/

[Weast, R.C. (ed.) Handbook of Chemistry and Physics. 69th ed. Boca Raton, FL: CRC Press Inc., 1988-1989., p. 1053] **\*\*PEER REVIEWED\*\***

Occupational exposure to **phosphine** may occur through inhalation with this compound at workplaces where **phosphine** is produced or used. Monitoring data suggest inhalation as the most likely pathway by which the general public is exposed to **phosphine**. (SRC)

**\*\*PEER REVIEWED\*\***

While a conservative 8-hour time-weighted average (TWA) of 0.1 ppm was calculated, the overall weight of evidence supports an occupational TWA of 0.3 ppm. In addition, a 15-minute short-term exposure limit (STEL) of 3 ppm was estimated. The MOE analysis does not indicate that fumigation workers are currently being exposed to unacceptable levels of **phosphine**.

[Pepelko B et al; Risk Anal 24 (5): 1201-13 (2004)] **\*\*PEER REVIEWED\*\*** [PubMed Abstract](#)

### Natural Pollution Sources:

FORMED IN SMALL QUANTITY IN PUTREFACTION OF ORG MATTER CONTAINING PHOSPHORUS.

[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989., p. 1165] **\*\*PEER REVIEWED\*\***

### Artificial Pollution Sources:

**PHOSPHINE** MAY BE EMITTED DURING STORAGE OF FERROUS ALLOYS (FERROSILICON AND SILICOCALCIUM). IT IS ALSO PRODUCED IN THE HYDROLYSIS OF PHOSPHIDES, AS DURING GALLIUM PHOSPHIDE GRINDING IN AQUEOUS SOLUTION AND DURING ACETYLENE GENERATION, WHEN WATER IS ADDED TO CALCIUM CARBIDE CONTAINING CALCIUM PHOSPHIDE AS AN IMPURITY.

[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983., p. 1681] **\*\*PEER REVIEWED\*\***

The sorption and desorption of **phosphine** from wheat treated with concn of 0.5-5 mg/kg wheat were determined at 25, 45, and 85 deg C. The desorbed **phosphine** was extracted from the air by passing through a cold trap. Most of

the **phosphine** was desorbed in the first 2-3 days but small amounts continued to desorb for many weeks following treatment. After 220 days of aeration, **phosphine** was still present and desorbing. Even when the temp was increased to 85 deg C for several days, unreacted **phosphine** still desorbed slowly from wheat. Corn aerated 26 days desorbed 0.004 ng/g in 2 days.

[Dumas T; J Agric Food Chem 28 (2): 337-39 (1980)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

**Phosphine**'s production as a by-product from the storage of ferrous alloys and phosphide hydrolysis(1) may result in its release to the environment through various waste streams(SRC). **Phosphine**'s use as a fumigant(2) will result in its direct release to the environment(SRC).

[(1) International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983.171. Gosselin RE et al, eds. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984 (2) Dumas T; J Agric Food Chem 28: 337-39 (1980)] \*\*PEER REVIEWED\*\*  
[PubMed Abstract](#)

## Environmental Fate:

TERRESTRIAL FATE: **Phosphine** is a gas(1) and therefore is expected to volatilize rapidly from both moist and dry soil(SRC). Studies have shown that sub-surface **phosphine** may bind to soil(2,3). Volatilization is expected to be the most important fate process since **phosphine** is a gas(SRC).

[(1) O'Neil MJ, ed; The Merck Index. 13th ed. Whitehouse Station, NJ: Merck and Co., Inc. p. 1316 (2001) (2) Spanggord RJ et al; Environmental Fate of White Phosphorous/Felt and Red Phosphorus/Butyl Rubber Military Screening Smokes. Phase 1. Literature Reviews NRIS AD-A150 754. Menlo Park, CA:SRI Inter. p 56 (1983) (3) USEPA/Office of Pesticide Programs; Pesticide Fact Sheet for Phosphine (December 1999). Available from the Database Query page at <http://www.epa.gov/oppr001/factsheets/> as of Apr 19, 2007.] \*\*PEER REVIEWED\*\*

AQUATIC FATE: **Phosphine** is a gas and therefore is expected to volatilize rapidly from water surfaces(1).

Biodegradation, hydrolysis and bioconcentration are not expected to be important fate processes when compared to volatilization(SRC).

[(1) O'Neil MJ, ed; The Merck Index. 13th ed. Whitehouse Station, NJ: Merck and Co., Inc. p. 1316 (2001)] \*\*PEER

REVIEWED\*\*

ATMOSPHERIC FATE: **Phosphine** is a gas at ambient temperature(1). Gas-phase **phosphine** is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); and has a reported atmospheric half-life of less than 1 day(2). **Phosphine** does not contain chromophores that absorb at wavelengths >290 nm and therefore is not expected to be susceptible to direct photolysis by sunlight(3).

[(1) O'Neil MJ, ed; The Merck Index. 13th ed. Whitehouse Station, NJ: Merck and Co., Inc. p. 1316 (2001) (2) Spicer CW et al; A literature review of atmospheric transformation products of clean air act. Title III hazardous air pollutants EPA Final Report , Research Triangle Park (1993) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 8-12 (1990)] \*\*PEER REVIEWED\*\*

### Environmental Abiotic Degradation:

PURE **PHOSPHINE** IS INERT, BUT WILL OXIDIZE UNDER INFLUENCE OF RADIATION & UV LIGHT.

[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982., p. 458] \*\*PEER REVIEWED\*\*

The half-life of **phosphine** in the atmosphere has been reported to be less than one day(1). Degradation of **phosphine** in the atmosphere is expected to predominately occur via photochemically-produced hydroxyl radicals(SRC). The half-life in air is approximately 5 hours with expected products being oxyacids of phosphorus and inorganic phosphate(2). **Phosphine** does not contain chromophores that absorb at wavelengths >290 nm and therefore is not expected to be susceptible to direct photolysis by sunlight(3).

[(1) Spicer CW et al; A literature review of atmospheric transformation products of clean air act. Title III hazardous air pollutants EPA Final Report, Research Triangle Park (1993) (2) USEPA/Office of Pesticide Programs; Pesticide Fact Sheet for Phosphine (December 1999). Available from the Database Query page at <http://www.epa.gov/opprd001/factsheets/> as of Apr 19, 2007. (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 7-4, 7-5, 8-12 (1990)] \*\*PEER REVIEWED\*\*

## Soil Adsorption/Mobility:

**Phosphine** is a gas(1) and expected to volatilize rapidly from water and both moist and dry soil(SRC) however studies have shown that **phosphine** may bind to soil(2). Laboratory studies do suggest that phosphine present below the soil surface is quickly adsorbed and degraded(3). A 50% degradation rate after 11 days in water saturated soil was observed using gaseous **phosphine** added to soil headspace at 1000 mg/kg dry soil in closed containers(3).

**Phosphine** interaction with soil is soil-type dependent(3).

[(1) O'Neil MJ, ed; The Merck Index. 13th ed. Whitehouse Station, NJ: Merck and Co., Inc. p. 1316 (2001) (2) Spanggord RJ et al; Environmental Fate of White Phosphorous/Felt and Red Phosphorus/Butyl Rubber Military Screening Smokes. Phase 1. Literature Reviews NRIS AD-A150 754. Menlo Park, CA:SRI Inter. p 56 (1983) (3) USEPA/Office of Pesticide Programs; Pesticide Fact Sheet for Phosphine (December 1999). Available from the Database Query page at <http://www.epa.gov/opprd001/factsheets/> as of Apr 19, 2007.] \*\*PEER REVIEWED\*\*

## Volatilization from Water/Soil:

**Phosphine** is a gas(1) and is expected to volatilize rapidly from water and moist and dry soils(SRC).

[(1) O'Neil MJ, ed; The Merck Index. 13th ed. Whitehouse Station, NJ: Merck and Co., Inc. p. 1316 (2001)] \*\*PEER REVIEWED\*\*

## Sediment/Soil Concentrations:

SEDIMENT: **Phosphine** was detected in sediment samples from paddy fields and reservoirs in Beijing at concentrations of 13 and 3.9 ng/kg, respectively(1).

[(1) Ji-Ang L et al; Water, Air Soil Pollution 116:597-604 (1999)] \*\*PEER REVIEWED\*\*

## Atmospheric Concentrations:

URBAN/SUBURBAN: **Phosphine** levels in Beijing, China typically were at their highest in the morning. Maximum concentrations at 6:00am and at noon were 65 and 11 ng/cu m, respectively(1). **Phosphine** concentrations in Beijing air were at their lowest during the spring and winter time(1).

[(1) Ji-Ang L et al; Water, Air Soil Pollution 116: 597-604 (1999)] \*\*PEER REVIEWED\*\*

SOURCE DOMINATED: **Phosphine** was detected in air samples taken in Beijing near a paddy field, at a water reservoir and the refuse tips as well adjacent ambient air. The maximum concentrations in paddy field, reservoir and landfill gas from refuse tips were 41, 135 and 1,062 ng/cu m, respectively(1). **Phosphine** was detected in ambient air at concentrations adjacent to these locations with maximum concentrations of 146, 166, and 71 for paddy field air, reservoir air and refuse tips air, respectively(1).

[(1) Ji-Ang L et al; Water, Air Soil Pollution 116: 597-604 (1999)] \*\*PEER REVIEWED\*\*

## Environmental Standards & Regulations:

### FIFRA Requirements:

Tolerances are established for residues of **phosphine** in or on the following raw agricultural commodities (RACs) resulting from post-harvest fumigation for the control of insects with **phosphine** gas or phosphide compounds that produce **phosphine** gas.

Commodity	
Almond	
Avocado	
Banana (including Plantains)	
Barley, grain	
Cabbage, Chinese	



Cacao bean, dried bean	
Cashew	
Citron, citrus	
Coffee, bean, green	
Corn, field, grain	
Corn, pop, grain	
Cotton, undelinted, seed	
Date, dried fruit	
Dill, seed	
Eggplant	
Endive	
Filbert	
Grapefruit	
Kumquat	
Lemon	
Lettuce	
Lime	
Mango	
Millet, grain	
Mushroom	
Nut, brazil	
Oat, grain	
Okra	

Orange, sweet	
Papaya	
Peanut	
Pecan	
Pepper	
Persimmon	
Pimento	
Pistachio	
Rice, grain	
Rye, grain	
Safflower, seed	
Salsify, tops	
Sesame, seed	
Sorghum, grain	
Soybean, seed	
Sunflower, seed	
Sweet potato, roots	
Tangelo	
Tangerine	
Tomato	
Vegetable, legume, group 6, except soybean	
Walnut	
Wheat, grain	

[40 CFR 180.225(a)(1); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations.  
Available from, as of August 30, 2006: <http://www.gpoaccess.gov/ecfr> \*\*PEER REVIEWED\*\*

Tolerances are established for residues of the fumigant in or on all RACs resulting from preharvest treatment of pest burrows in agricultural and non-crop land areas: All raw agricultural commodities resulting from preharvest treatment of pest burrows.

[40 CFR 180.225(a)(2); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations.  
Available from, as of August 30, 2006: <http://www.gpoaccess.gov/ecfr> \*\*PEER REVIEWED\*\*

Residues resulting from fumigation of processed foods: Processed foods.

[40 CFR 180.225(a)(3); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations.  
Available from, as of August 30, 2006: <http://www.gpoaccess.gov/ecfr> \*\*PEER REVIEWED\*\*

Residues resulting from fumigation of animal feed: Animal feed.

[40 CFR 180.225(a)(4); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations.  
Available from, as of August 30, 2006: <http://www.gpoaccess.gov/ecfr> \*\*PEER REVIEWED\*\*

To assure safe use of this pesticide, it must be used in compliance with the labeling conforming to that registered by the U.S. Environmental Protection Agency (EPA) under FIFRA. Labeling shall bear a restriction to aerate the finished food/feed for 48 hours before it is offered to the consumer, unless EPA specifically determines that a different time period is appropriate. Where appropriate, a warning shall state that under no condition should any formulation containing aluminum or magnesium phosphide be used so that it will come in contact with any processed food, except processed brewer's rice, malt, and corn grits stored in breweries for use in the manufacture of beer.

[40 CFR 180.225(a)(5); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations.  
Available from, as of August 30, 2006: <http://www.gpoaccess.gov/ecfr> \*\*PEER REVIEWED\*\*

## **CERCLA Reportable Quantities:**

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 100 lb or 45.4 kg. The toll free number of the NRC is (800) 424-8802. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV. D.3.b).

[40 CFR 302.4; U.S. National Archives and Records Administration's Electronic Code of Federal Regulations.

Available from, as of August 30, 2006: <http://www.gpoaccess.gov/ecfr> \*\*PEER REVIEWED\*\*

Releases of CERCLA hazardous substances are subject to the release reporting requirement of CERCLA section 103, codified at 40 CFR part 302, in addition to the requirements of 40 CFR part 355. **Phosphine** is an extremely hazardous substance (EHS) subject to reporting requirements when stored in amounts in excess of its threshold planning quantity (TPQ) of 500 lbs.

[40 CFR 355; U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of August 30, 2006: <http://www.gpoaccess.gov/ecfr> \*\*PEER REVIEWED\*\*

## RCRA Requirements:

P096; As stipulated in 40 CFR 261.33, when **phosphine**, as a commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate, becomes a waste, it must be managed according to federal and/or state hazardous waste regulations. Also defined as a hazardous waste is any container or inner liner used to hold this waste or any residue, contaminated soil, water, or other debris resulting from the cleanup of a spill, into water or on dry land, of this waste. Generators of small quantities of this waste may qualify for partial exclusion from hazardous waste regulations (40 CFR 261.5(e)).

[40 CFR 261.33; U.S. National Archives and Records Administration's Electronic Code of Federal Regulations.

Available from, as of August 30, 2006: <http://www.gpoaccess.gov/ecfr> \*\*PEER REVIEWED\*\*

## Atmospheric Standards:

Listed as a hazardous air pollutant (HAP) generally known or suspected to cause serious health problems. The Clean Air Act, as amended in 1990, directs EPA to set standards requiring major sources to sharply reduce routine emissions of toxic pollutants. EPA is required to establish and phase in specific performance based standards for all air emission sources that emit one or more of the listed pollutants. **Phosphine** is included on this list.

[Clean Air Act as amended in 1990, Sect. 112 (b) (1) Public Law 101-549 Nov. 15, 1990] \*\*PEER REVIEWED\*\*

### State Drinking Water Guidelines:

(FL) FLORIDA 125 ug/L

[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present] \*\*PEER REVIEWED\*\*

### Allowable Tolerances:

Tolerances are established for residues of **phosphine** in or on the following raw agricultural commodities (RACs) resulting from post-harvest fumigation for the control of insects with **phosphine** gas or phosphide compounds that produce **phosphine** gas.

Commodity	Parts per million
Almond	0.1
Avocado	0.01
Banana (including Plantains)	0.01
Barley, grain	0.1
Cabbage, Chinese	0.01
Cacao bean, dried bean	0.1

Cashew	0.1
Citron, citrus	0.01
Coffee, bean, green	0.1
Corn, field, grain	0.1
Corn, pop, grain	0.1
Cotton, undelinted, seed	0.1
Date, dried fruit	0.1
Dill, seed	0.01
Eggplant	0.01
Endive	0.01
Filbert	0.1
Grapefruit	0.01
Kumquat	0.01
Lemon	0.01
Lettuce	0.01
Lime	0.01
Mango	0.01
Millet, grain	0.1
Mushroom	0.01
Nut, brazil	0.1
Oat, grain	0.1
Okra	0.01
Orange, sweet	0.01

Papaya	0.01
Peanut	0.1
Pecan	0.1
Pepper	0.01
Persimmon	0.01
Pimento	0.01
Pistachio	0.1
Rice, grain	0.1
Rye, grain	0.1
Safflower, seed	0.1
Salsify, tops	0.01
Sesame, seed	0.1
Sorghum, grain	0.1
Soybean, seed	0.1
Sunflower, seed	0.1
Sweet potato, roots	0.01
Tangelo	0.01
Tangerine	0.01
Tomato	0.01
Vegetable, legume, group 6, except soybean	0.01
Walnut	0.1
Wheat, grain	0.1

[40 CFR 180.225(a)(1); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations.  
Available from, as of August 30, 2006: <http://www.gpoaccess.gov/ecfr> \*\*PEER REVIEWED\*\*

Tolerances are established for residues of the fumigant in or on all RACs resulting from preharvest treatment of pest burrows in agricultural and non-crop land areas. All raw agricultural commodities resulting from preharvest treatment of pest burrows, 0.01 ppm.

[40 CFR 180.225(a)(2); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations.  
Available from, as of August 30, 2006: <http://www.gpoaccess.gov/ecfr> \*\*PEER REVIEWED\*\*

Residues resulting from fumigation of processed foods: Processed foods, 0.01 ppm.

[40 CFR 180.225(a)(3); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations.  
Available from, as of August 30, 2006: <http://www.gpoaccess.gov/ecfr> \*\*PEER REVIEWED\*\*

Residues resulting from fumigation of animal feed: Animal feed, 0.1 ppm.

[40 CFR 180.225(a)(4); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations.  
Available from, as of August 30, 2006: <http://www.gpoaccess.gov/ecfr> \*\*PEER REVIEWED\*\*

To assure safe use of this pesticide, it must be used in compliance with the labeling conforming to that registered by the U.S. Environmental Protection Agency (EPA) under FIFRA. Labeling shall bear a restriction to aerate the finished food/feed for 48 hours before it is offered to the consumer, unless EPA specifically determines that a different time period is appropriate. Where appropriate, a warning shall state that under no condition should any formulation containing aluminum or magnesium phosphide be used so that it will come in contact with any processed food, except processed brewer's rice, malt, and corn grits stored in breweries for use in the manufacture of beer.

[40 CFR 180.225(a)(5); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations.  
Available from, as of August 30, 2006: <http://www.gpoaccess.gov/ecfr> \*\*PEER REVIEWED\*\*



## Chemical/Physical Properties:

### Molecular Formula:

H<sub>3</sub>-P

**\*\*PEER REVIEWED\*\***

### Molecular Weight:

34.00

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. 13th Edition, Whitehouse Station, NJ: Merck and Co., Inc., 2001., p. 1316] **\*\*PEER REVIEWED\*\***

### Color/Form:

Colorless gas [Note: Shipped as a liquefied compressed gas].

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **\*\*PEER REVIEWED\*\***

### Odor:

Disagreeable, garlic-like odor.

[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 14th Edition. John Wiley & Sons, Inc. New York, NY 2001., p. 869] **\*\*PEER REVIEWED\*\***

ALMOST ODORLESS IN PUREST FORM, BUT ODOR OF DECAYING FISH WHEN OCCURRING INDUSTRIALLY.

[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986., p. 826] \*\*PEER REVIEWED\*\*

Foul odor of decaying fish

[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 10th ed. Volumes 1-3 New York, NY: John Wiley & Sons Inc., 1999., p. V3: 2943] \*\*PEER REVIEWED\*\*

Fish- or garlic-like odor [Note: Pure compound is odorless].

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

### Boiling Point:

-87.7 deg C

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. 13th Edition, Whitehouse Station, NJ: Merck and Co., Inc., 2001., p. 1316] \*\*PEER REVIEWED\*\*

### Melting Point:

-133 deg C

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. 13th Edition, Whitehouse Station, NJ: Merck and Co., Inc., 2001., p. 1316] \*\*PEER REVIEWED\*\*

### Critical Temperature & Pressure:

CRITICAL PRESSURE: 65 ATM; CRITICAL TEMP: 52 DEG C.

[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982., p. 458] \*\*PEER REVIEWED\*\*

### Density/Specific Gravity:

1.185

[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 14th Edition. John Wiley & Sons, Inc. New York, NY 2001., p. 869] \*\*PEER REVIEWED\*\*

### pH:

SOLN ARE NEUTRAL

[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984., p. II-119] \*\*PEER REVIEWED\*\*

### Solubilities:

Slightly sol in water (0.26 vol at 20 deg C)

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. 13th Edition, Whitehouse Station, NJ: Merck and Co., Inc., 2001., p. 1316] \*\*PEER REVIEWED\*\*

Soluble in alcohol, ether, and cuprous chloride solution; sl sol in cold water. Insoluble in hot water.

[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 14th Edition. John Wiley & Sons, Inc. New York, NY 2001., p. 869] \*\*PEER REVIEWED\*\*

## Spectral Properties:

Index of refraction: 1.317 (liq)

[Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979., p. B-83] \*\*PEER REVIEWED\*\*

MASS: 2 (National Bureau of Standards EPA-NIH Mass Spectra Data Base, NSRDS-NBS-63)

[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985., p. V2 104] \*\*PEER REVIEWED\*\*

## Vapor Density:

1.17 (AIR= 1)

[National Fire Protection Association. Fire Protection Guide on Hazardous Materials. 9th ed. Boston, MA: National Fire Protection Association, 1986., p. 325M-158] \*\*PEER REVIEWED\*\*

## Vapor Pressure:

2.93X10+4 mm Hg at 25 deg C

[Daubert, T.E., R.P. Danner. Physical and Thermodynamic Properties of Pure Chemicals Data Compilation. Washington, D.C.: Taylor and Francis, 1989., p. 458] \*\*PEER REVIEWED\*\*

## Other Chemical/Physical Properties:

Liberates hydrogen and forms phosphide when passed over heated metal; forms phosphonium salts when brought in contact with halogen acids.

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. 13th Edition,

Whitehouse Station, NJ: Merck and Co., Inc., 2001., p. 1316] \*\*PEER REVIEWED\*\*

Extremely weak base

[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 10th ed. Volumes 1-3 New York, NY: John Wiley & Sons Inc., 1999., p. V3: 2943] \*\*PEER REVIEWED\*\*

Density: 1.529 g/L at 0 deg C

[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 10th ed. Volumes 1-3 New York, NY: John Wiley & Sons Inc., 1999., p. V3: 2943] \*\*PEER REVIEWED\*\*

Henry's Law constant =  $2.44 \times 10^{-2}$  atm-cu m/mol at 25 deg C (est)

[US EPA; Estimation Program Interface (EPI) Suite. Ver.3.12. Nov 30, 2004. Available from, as of Apr 19, 2007: <http://www.epa.gov/oppt/exposure/pubs/episutedl.htm> \*\*PEER REVIEWED\*\*

## Chemical Safety & Handling:

### DOT Emergency Guidelines:

If ... THERE IS NO FIRE, go directly to the Table of Initial Isolation and Protective Action Distances /(see table below)/ ... to obtain initial isolation and protective action distances. IF THERE IS A FIRE, or IF A FIRE IS INVOLVED, go directly to the appropriate guide /(see guide(s) below)/ and use the evacuation information shown under PUBLIC SAFETY.

**Table of Initial Isolation and Protective Action Distances for Phosphine**

Small Spills (from a small package or small leak from a large package)			Large Spills (from a large package or small leak from a large package)		
First ISOLATE in	Then PROTECT	Then PROTECT persons	First ISOLATE in	Then PROTECT	Then PROTECT persons

<b>all Directions</b>	<b>persons Downwind during DAY:</b>	<b>Downwind during NIGHT :</b>	<b>all Directions</b>	<b>persons Downwind during DAY:</b>	<b>Downwind during NIGHT:</b>
60 m (200 ft)	0.2 km (0.2 mi)	1.0 km (0.7 mi)	400 m (1250 ft)	1.3 km (0.8 mi)	4.1 km (2.5 mi)

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] \*\*PEER REVIEWED\*\*

/GUIDE 119: GASES - TOXIC - FLAMMABLE/ Fire or Explosion: Flammable; may be ignited by heat, sparks or flames. May form explosive mixtures with air. Those substances designated with a (P) may polymerize explosively when heated or involved in a fire. Vapors from liquefied gas are initially heavier than air and spread along ground. Vapors may travel to source of ignition and flash back. Some of these materials may react violently with water. Cylinders exposed to fire may vent and release toxic and flammable gas through pressure relief devices. Containers may explode when heated. Ruptured cylinders may rocket. Runoff may create fire or explosion hazard.

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] \*\*PEER REVIEWED\*\*

/GUIDE 119: GASES - TOXIC - FLAMMABLE/ Health: TOXIC; may be fatal if inhaled or absorbed through skin. Contact with gas or liquefied gas may cause burns, severe injury and/or frostbite. Fire will produce irritating, corrosive and/or toxic gases. Runoff from fire control may cause pollution.

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] \*\*PEER REVIEWED\*\*

/GUIDE 119: GASES - TOXIC - FLAMMABLE/ Public Safety: CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover. As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Many gases are heavier than air and will spread along ground and collect in low or confined areas (sewers, basements, tanks). Keep out of low areas. Ventilate closed spaces before entering.

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] \*\*PEER  
REVIEWED\*\*

/GUIDE 119: GASES - TOXIC - FLAMMABLE/ Protective Clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Wear chemical protective clothing that is specifically recommended by the manufacturer. It may provide little or no thermal protection. Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations where direct contact with the substance is possible.

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] \*\*PEER  
REVIEWED\*\*

/GUIDE 119: GASES - TOXIC - FLAMMABLE/ Evacuation: Spill: See Table 1 - Initial Isolation and Protective Action Distances for highlighted materials. For non-highlighted materials, increase, in the downwind direction, as necessary, the isolation distance shown under "PUBLIC SAFETY". Fire: If tank, rail car or tank truck is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions.

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] \*\*PEER  
REVIEWED\*\*

/GUIDE 119: GASES - TOXIC - FLAMMABLE/ Fire: DO NOT EXTINGUISH A LEAKING GAS FIRE UNLESS LEAK CAN BE STOPPED. Small Fire: Dry chemical, CO2, water spray or alcohol-resistant foam. Large Fire: Water spray, fog or alcohol-resistant foam. FOR CHLOROSILANES, DO NOT USE WATER; use AFFF alcohol-resistant medium expansion foam. Move containers from fire area if you can do it without risk. Damaged cylinders should be handled only by specialists. Fire involving Tanks: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Do not direct water at source of leak or safety devices; icing may occur. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire.

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] \*\*PEER  
REVIEWED\*\*

/GUIDE 119: GASES - TOXIC - FLAMMABLE/ Spill or Leak: ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. Fully encapsulating, vapor protective clothing should be worn for spills and leaks with no fire. Do not touch or walk through spilled material. Stop leak if you can do it without risk. Do not direct water at spill or source of leak. Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material. FOR CHLOROSILANES, use AFFF alcohol-resistant medium expansion foam to reduce vapors. If possible, turn leaking containers so that gas escapes rather than liquid. Prevent entry into waterways, sewers, basements or confined areas. Isolate area until gas has dispersed.

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] \*\*PEER REVIEWED\*\*

/GUIDE 119: GASES - TOXIC - FLAMMABLE/ First Aid: Move victim to fresh air. Call 911 or emergency medical service. Give artificial respiration if victim is not breathing. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. In case of contact with liquefied gas, thaw frosted parts with lukewarm water. In case of burns, immediately cool affected skin for as long as possible with cold water. Do not remove clothing if adhering to skin. Keep victim warm and quiet. Keep victim under observation. Effects of contact or inhalation may be delayed. Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] \*\*PEER REVIEWED\*\*

## Odor Threshold:

0.03 PPM

[Thienes, C., and T.J. Haley. Clinical Toxicology. 5th ed. Philadelphia: Lea and Febiger, 1972., p. 193] \*\*PEER REVIEWED\*\*



Air: 0.51 uL/L; Water: 0.0002 mg/L; Odor Safety Class: D; D= 10-50% of attentive persons can detect TLV concn in the air.

[Amoore JE, Hautala E; J Appl Toxicol 3 (6): 272-90 (1983)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

**Phosphine**'s characteristic decayed fish odor is barely detectable at concentrations of 1.5 to 3 ppm.

[Bingham, E.; Cohrssen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. 3:472] \*\*PEER REVIEWED\*\*

**Phosphine** has a fishy or garlic-like odor, detectable at about 2 ppm, but this odor threshold does not provide sufficient warning of toxic exposure.

[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994, p. 638] \*\*PEER REVIEWED\*\*

## Skin, Eye and Respiratory Irritations:

Irritating to skin, eyes, and respiratory system.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 49-117] \*\*PEER REVIEWED\*\*

## Fire Potential:

Pure **phosphine** does not spontaneously ignite in air below 150 deg C unless it is thoroughly dried, when it ignites in cold air. The presence of traces (0.2%) of diphosphane in **phosphine** as normally prepared causes it to ignite spontaneously in air, even at below -15 deg C ... Traces of oxidants promote pyrophoricity.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1237] \*\*PEER REVIEWED\*\*

SPONTANEOUSLY FLAMMABLE IN AIR IF THERE IS TRACE OF DIPHOSPHOROUS HYDRIDE PRESENT;

BURNS WITH LUMINOUS FLAME.

[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989., p. 1165] \*\*PEER REVIEWED\*\*

Flammable gas. Pyrophoric; may ignite spontaneously in air or accumulate and explode in air without source of ignition ...

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 49-117] \*\*PEER REVIEWED\*\*

### **NFPA Hazard Classification:**

Health: 4. 4= Materials that, on very short exposure, could cause death or major residual injury, including those that are too dangerous to be approached without specialized protective equipment. A few whiffs of the vapor or gas can cause death, or contact with the vapor or liquid may be fatal, if it penetrates the fire fighter's normal protective gear. The normal full protective clothing and breathing apparatus available to the typical fire fighter will not provide adequate protection against inhalation or skin contact with these materials.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002.]

\*\*PEER REVIEWED\*\*

Flammability: 4. 4= This degree includes flammable gases, flammable cryogenic materials, pyrophoric liquids, and Class IA flammable liquids. The preferred method of fire attack is to stop the flow of material or to protect exposures while allowing the fire to burn itself out.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002.]

\*\*PEER REVIEWED\*\*

Instability: 2. 2= Materials that can undergo violent chemical changes at elevated temperatures and pressures. This also includes materials that may react violently with water or that may form potentially explosive mixtures with water. In advanced or massive fires involving these materials, fire fighting should be done from a safe distance or from a protected location.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002.]

**\*\*PEER REVIEWED\*\***

## Flammable Limits:

Lower flammable limit: 1.6% by volume; Upper flammable limit: 98 (est) % by volume

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 325-99] **\*\*PEER REVIEWED\*\***

Lower flammability limit of pure **phosphine** in moist air (0.39 vol% water vapor) at 1037 mbar was 2.1% at 10 deg C and 1.85% at 50 deg C. Presence of ammonia may tend to reduce the limit value.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1238] **\*\*PEER REVIEWED\*\***

## Autoignition Temperature:

212 deg F (100 deg C)

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 325-99] **\*\*PEER REVIEWED\*\***

## Fire Fighting Procedures:

Evacuation: If fire becomes uncontrollable or container is exposed to direct flame - consider evacuation of one-third (1/3) mile radius.

[Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 715] **\*\*PEER REVIEWED\*\***

If material on fire or involved in fire: Do not extinguish fire unless flow can be stopped. Use water in flooding quantities as fog. Cool all affected containers with flooding quantities of water. Apply water from as far a distance as possible. Solid streams of water may be ineffective. Use foam, dry chemical, or carbon dioxide.

[Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 715] \*\*PEER REVIEWED\*\*

Extinguishing Methods: do not use halocarbons.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 325-99] \*\*PEER REVIEWED\*\*

Approach fire from upwind to avoid hazardous vapors and toxic decomp products. Explosive decomp may occur under fire conditions ... Stop flow of gas before extinguishing fire ...

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 49-117] \*\*PEER REVIEWED\*\*

## Firefighting Hazards:

Evolves hydrogen and ignites on contact with many materials. Vapors are heavier than air and may travel to a source of ignition and flash back. Closed containers may rupture violently when heated.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 49-117] \*\*PEER REVIEWED\*\*

## Explosive Limits & Potential:

IT IS DANGEROUS ... EXPLOSION ... HAZARD.

[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983., p. 1681] \*\*PEER REVIEWED\*\*

LOWEST EXPLOSION LIMIT IN AIR 1.79 VOL % OR 26 G/CU M.

[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982., p. 458] \*\*PEER REVIEWED\*\*

Liquefied **phosphine** (a mildly endothermic cmpd, standard heat of formation +22.8 kJ/mol, 0.67 kJ/g) can be detonated by powerful initiation.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1237] \*\*PEER REVIEWED\*\*

... May ignite spontaneously in air or accumulate and explode in air without source of ignition ... Closed containers may rupture violently when heated.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 49-117] \*\*PEER REVIEWED\*\*

## **Hazardous Reactivities & Incompatibilities:**

COMBINES VIOLENTLY WITH OXYGEN & HALOGENS.

[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989., p. 1058] \*\*PEER REVIEWED\*\*

REACTS WITH COPPER, SILVER, GOLD, & THEIR SALTS.

[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982., p. 458] \*\*PEER REVIEWED\*\*

Air, oxidizers, chlorine, acids, moisture, halogenated hydrocarbons, copper [Note: May ignite SPONTANEOUSLY on contact with air].

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

**Phosphine**, generated by action of water on calcium phosphide, was dried by passage through towers packed with the latter. Soon after refilling the generator (but not the towers) and starting purging with argon, a violent explosion occurred. This was attributed to the air, displaced from the generator by argon, reacting explosively with dry **phosphine** present in the drying towers, possibly catalyzed by the orange-yellow polyphosphine formed on the surface of calcium phosphide. Fresh calcium phosphide in both generator and drying towers, with separate purging, is recommended.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1237] \*\*PEER REVIEWED\*\*

During vacuum transfer of the supposedly pure gas, air leaked into the cold-trap system and caused an explosion.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1238] \*\*PEER REVIEWED\*\*

The presence of traces (0.2%) of diphosphane in **phosphine** as normally prepared causes it to ignite spontaneously in air, even at below -15 deg C ... **Phosphine**, generated by action of the alkali on phosphonium iodide, was shown to be pure by mass spectrometry. During a second prepn, an air leak developed during cold-trap transfer and an explosion occurred. Presence of diphosphane was suspected.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1241] \*\*PEER REVIEWED\*\*

Interaction /between **phosphine** and boron trichloride/ is energetic.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 59] \*\*PEER REVIEWED\*\*

The heat sensitivity ... may explain the explosions which occur on contact of many readily oxidizable materials /eg, **phosphine**/ with the powerful oxidant dichlorine oxide ...

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1023] \*\*PEER REVIEWED\*\*

Ignition /of **phosphine**/ occurs on contact with chlorine or bromine or their aq soln.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1238] \*\*PEER REVIEWED\*\*

Passage of **phosphine** into silver nitrate soln causes ignition or explosion, depending on the gas rate. Mercury(II) nitrate soln gives a complex phosphide, explosive when dry.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1238] \*\*PEER REVIEWED\*\*

The reaction of ... /**phosphine** and mercuric nitrate/ gives a yellow precipitate which explodes when heated or subjected to shock.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 491-117] \*\*PEER REVIEWED\*\*

**Phosphine** is violently decomp by concn nitric acid, and flame is produced.; Warm fuming nitric acid, dropped in a container of **phosphine** gas, produces an explosion.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 491-145] \*\*PEER REVIEWED\*\*

... /**Phosphine**/ will initiate the violent and often explosive decomp of nitrogen trichloride.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1041] \*\*PEER REVIEWED\*\*

Pure **phosphine** is rendered pyrophoric by traces of dinitrogen trioxide, nitrous acid, or similar oxidant.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1238] \*\*PEER REVIEWED\*\*

Even small amt of oxygen present in **phosphine** give an explosive mixture, in which autoignition occurs at low

pressures ...

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1238] \*\*PEER REVIEWED\*\*

**Phosphine** plus nitric oxide can be ignited by the addition of oxygen.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 491-146] \*\*PEER REVIEWED\*\*

A mixture of nitrous oxide and **phosphine** can be exploded by a spark.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 491-146] \*\*PEER REVIEWED\*\*

Potassium and **phosphine** react in liq ammonia to form potassium dihydrophosphide, a spontaneously flammable solid.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 491-156] \*\*PEER REVIEWED\*\*

## Hazardous Decomposition:

When heated to decomp ... emits toxic fumes of /phosphorus oxides/.

[Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984., p. 2212] \*\*PEER REVIEWED\*\*

## Immediately Dangerous to Life or Health:

50 ppm

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS



(NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

## Protective Equipment & Clothing:

PERSONAL RESP PROTECTION ... NECESSARY, INCL CANISTER-TYPE GAS MASKS FOR LOWER LEVELS OF CONTAMINATION & OTHERWISE, SELF-CONTAINED BREATHING APPARATUS. ... SAFETY GOGGLES & PROTECTIVE CLOTHING.

[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983., p. 1681] \*\*PEER REVIEWED\*\*

Compressed gases may create low temperatures when they expand rapidly. Leaks and uses that allow rapid expansion may cause a frostbite hazard. Wear appropriate personal protective clothing to prevent the skin from becoming frozen.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

Wear appropriate eye protection to prevent eye contact with the liquid that could result in burns or tissue damage from frostbite.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

Quick drench facilities and/or eyewash fountains should be provided within the immediate work area for emergency use where there is any possibility of exposure to liquids that are extremely cold or rapidly evaporating.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

Respirator Recommendations: Up to 3 ppm: (Assigned Protection Factor = 10) Any supplied-air respirator.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

Respirator Recommendations: Up to 7.5 ppm: (Assigned Protection Factor = 25) Any supplied-air respirator operated in a continuous-flow mode.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

Respirator Recommendations: Up to 15 ppm: (Assigned Protection Factor = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern./ (Assigned Protection Factor = 50) Any self-contained breathing apparatus with a full facepiece./ (Assigned Protection Factor = 50) Any supplied-air respirator with a full facepiece.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

Respirator Recommendations: Up to 50 ppm: (Assigned Protection Factor = 1000) Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

Respirator Recommendations: Emergency or planned entry into unknown concentrations or IDLH conditions: (Assigned Protection Factor = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode./ (Assigned Protection Factor = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure

mode in combination with an auxiliary self-contained positive-pressure breathing apparatus.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

Escape: (Assigned Protection Factor = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern/Any appropriate escape-type, self-contained breathing apparatus.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

## Preventive Measures:

It is a violation of federal law to use this product in a manner inconsistent with its labeling or application manual.

VAPORPH3OS **Phosphine** Fumigant is a restricted use Pesticide due to the acute inhalation toxicity of **phosphine** gas. For retail sale to Dealers and Certified Applicators only. For use by Certified Applicators or persons under their direct supervision, and only for those uses covered by the Certified Applicator's certification. Refer to the directions in the application manual for requirements of the physical presence of a Certified Applicator./VAPORPH3OS

**Phosphine** Fumigant/

[EPA; Pesticide Product Label System (PPLS) - Search Results for VAPORPH3OS Phosphine Fumigant. Product Label approved by EPA on December 27, 2005. Available from, as of April 23, 2007: <http://oaspub.epa.gov> \*\*PEER REVIEWED\*\*

SRP: The scientific literature for the use of contact lenses in industry is conflicting. The benefit or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In

any event, the usual eye protection equipment should be worn even when contact lenses are in place.

**\*\*PEER REVIEWED\*\***

SRP: Local exhaust ventilation should be applied wherever there is an incidence of point source emissions or dispersion of regulated contaminants in the work area. Ventilation control of the contaminant as close to its point of generation is both the most economical and safest method to minimize personnel exposure to airborne contaminants.

**\*\*PEER REVIEWED\*\***

SRP: Contaminated protective clothing should be segregated in such a manner so that there is no direct personal contact by personnel who handle, dispose, or clean the clothing. Quality assurance to ascertain the completeness of the cleaning procedures should be implemented before the decontaminated protective clothing is returned for reuse by the workers. Contaminated clothing should not be taken home at end of shift, but should remain at employee's place of work for cleaning.

**\*\*PEER REVIEWED\*\***

CONTROL MEASURES INCL /EXHAUST/ VENTILATION /FROM FLOOR/, WHICH SHOULD BE IN DOWNWARD DIRECTION SINCE GAS IS HEAVIER THAN AIR.

[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland:

International Labour Office, 1983., p. 1681] **\*\*PEER REVIEWED\*\***

Work clothing that becomes wet should be immediately removed due to its flammability hazard (i.e., for liquids with a flash point <100 deg F).

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **\*\*PEER REVIEWED\*\***

If material not on fire and not involved in fire: Keep sparks, flames, and other sources of ignition away. Keep material out of water sources and sewers. Attempt to stop leak if without undue personnel hazard use water spray to knock-down vapors.

[Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 715] \*\*PEER REVIEWED\*\*

Personnel protection: Avoid breathing vapors. Keep upwind. ... Avoid bodily contact with the material. ... Do not handle broken packages unless wearing appropriate personal protective equipment. Wash away any material which may have contacted the body with copious amounts of water or soap and water.

[Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 715] \*\*PEER REVIEWED\*\*

If material not on fire and not involved in fire: Keep sparks, flames, and other sources of ignition away. Keep material out of water sources and sewers. attempt to stop leak if without undue personnel hazard. Use water spray to knock-down vapors.

[Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 715] \*\*PEER REVIEWED\*\*

Evacuation: ... If material leaking (not on fire) consider evacuation from downwind area based on amount of material spilled, location and weather conditions.

[Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 715] \*\*PEER REVIEWED\*\*

### **Stability/Shelf Life:**

STABLE UP TO 55 DEG C

[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982., p. 458] \*\*PEER REVIEWED\*\*

### **Shipment Methods and Regulations:**

No person may /transport,/ offer or accept a hazardous material for transportation in commerce unless that person is registered in conformance ... and the hazardous material is properly classed, described, packaged, marked, labeled, and in condition for shipment as required or authorized by ... /the hazardous materials regulations (49 CFR 171-177)./ [49 CFR 171.2; U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of February 15, 2006: <http://www.gpoaccess.gov/ecfr/> \*\*PEER REVIEWED\*\*

The International Air Transport Association (IATA) Dangerous Goods Regulations are published by the IATA Dangerous Goods Board pursuant to IATA Resolutions 618 and 619 and constitute a manual of industry carrier regulations to be followed by all IATA Member airlines when transporting hazardous materials. [International Air Transport Association. Dangerous Goods Regulations. 47th Edition. Montreal, Quebec Canada. 2006., p. 237] \*\*PEER REVIEWED\*\*

The International Maritime Dangerous Goods Code lays down basic principles for transporting hazardous chemicals. Detailed recommendations for individual substances and a number of recommendations for good practice are included in the classes dealing with such substances. A general index of technical names has also been compiled. This index should always be consulted when attempting to locate the appropriate procedures to be used when shipping any substance or article. [International Maritime Organization. International Maritime Dangerous Goods Code. London, UK. 2004., p. 102] \*\*PEER REVIEWED\*\*

## Storage Conditions:

STORAGE INSTRUCTIONS. INDOOR STORAGE The storage of poison gases in occupied spaces is not recommended. Indoor storage in a separate building with no other occupancy is suitable. The building should be adequately ventilated and equipped with a continuous **phosphine** monitoring and alarm system that is activated at the TLV of 0.3 ppm. In some jurisdictions, the indoor storage of toxic gases is prohibited. OUTDOOR STORAGE. It is recommended that both full and used VAPORPH3OS **Phosphine** Fumigant cylinders be stored outdoors in a dedicated and properly designed and labeled storage area. The following are recommended for outdoor storage: A

firm and level surface, preferably reinforced concrete, well drained. A secured and locked area. Cylinders should never be stored where the temperature will exceed 125 deg F (51.7 deg C). A means of securing all cylinders. Away from building ventilation intakes. SECURING CYLINDERS. Cylinders must be stored in an upright position and protected from falling. Protection against falls can include the use of cylinder pallets with straps, walls and securing chains, or pens constructed from steel handrail or like construction. /VAPORPH3OS **Phosphine** Fumigant/ [EPA; Pesticide Product Label System (PPLS) - Search Results for VAPORPH3OS Phosphine Fumigant. Product Label Available from, as of April 23, 2007: <http://oaspub.epa.gov> \*\*PEER REVIEWED\*\*

Store in a cool, dry, well-ventilated location. Separate from acids, alkalies, and halogenated cmpd. Outside or detached storage is preferred.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 49-117] \*\*PEER REVIEWED\*\*

... MUST BE STORED IN COOL, DRY, ISOLATED AREA, AWAY FROM ACUTE FIRE HAZARDS & POWERFUL OXIDIZING MATERIALS. CONTAINERS SHOULD BE KEPT CLOSED & PLAINLY LABELLED.

[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983., p. 1681] \*\*PEER REVIEWED\*\*

## Cleanup Methods:

ARSINE AND **PHOSPHINE** WERE REMOVED FROM WASTE GASES OF SEMICONDUCTOR MANUFACTURE BY OZONE OXIDATION AND CARBON ADSORPTION.

[NISHIMURA S, WATANABE M; JAPAN KOKAI PATENT 76 11068 01/28/76] \*\*PEER REVIEWED\*\*

Porous supports (pearlite or aluminum oxide) impregnated with aqueous silver nitrate, or with aqueous ferric chloride containing other metal salts are used for purging of **phosphine** in waste gas from a semiconductor plant.

[Toyo Sanso KK; Jpn Kokai Tokkyo Koho Patent No 81 89837 07/21/81 (Toyo Sanso KK)] \*\*PEER REVIEWED\*\*

Poisonous gases, including **phosphine**, are diluted with nitrogen or neon and injected into an aqueous foaming

agent, preferably under paraffin.

[Matsushita Electric Industrial Co, Ltd; Jpn Kokai Tokkyo Koho Patent No 81 73522 06/18/81 (Matsushita Electric Industrial Co, Ltd)] \*\*PEER REVIEWED\*\*

Stop or control the leak, if this can be done without undue risk. Use water spray to cool and disperse vapors and protect personnel. Approach release from upwind.

[Fire Protection Guide to Hazardous Materials. 13 ed. Quincy, MA: National Fire Protection Association, 2002., p. 49-117] \*\*PEER REVIEWED\*\*

SPILL AND LEAK PROCEDURES: GENERAL. All releases can produce high levels of gas, and therefore, attending personnel must wear a self-contained breathing apparatus (SCBA) or its equivalent when the concentration of **phosphine** gas is unknown. If the concentration is known, other NIOSH ... approved respiratory protection must be worn. WHAT TO DO. In the event of an accidental release, evacuate the area immediately. A response into the leak area should only be attempted by trained emergency responders. If it is possible to shut off the source of the leak from a remote area, it should be done. Otherwise, evacuate the area and call for assistance.... EMERGENCY RESPONDERS. All emergency responses should be made in level B protection, which includes neoprene, butyl rubber or PVC gloves, Seranex coated Tyvek suit, rubber boots and an air-supplied respirator. Refer to the Application manual for more detailed recommendations for handling, storage, spill and leak procedures.

/VAPORPH3OS **Phosphine** Fumigant/

[EPA; Pesticide Product Label System (PPLS) - Search Results for VAPORPH3OS Phosphine Fumigant. Product Label approved by EPA on December 27, 2005. Available from, as of April 23, 2007: <http://oaspub.epa.gov> \*\*PEER REVIEWED\*\*

## Disposal Methods:

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number P096, must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.

[40 CFR 240-280, 300-306, 702-799 (7/1/89)] \*\*PEER REVIEWED\*\*



A potential candidate for rotary kiln incineration at a temperature range of 820 to 1,600 deg C and residence times of seconds for liquids and gases, and hours for solids. A potential candidate for fluidized bed incineration at a temperature range of 450 to 980 deg C and residence times of seconds for liquids and gases, and longer for solids.

[USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-10 (1981) EPA 68-03-3025] \*\*PEER REVIEWED\*\*

Surplus gas or leaking cylinder can be vented slowly to air in a safe, open area or gas burnt off through a suitable burner in a fume cupboard. Recommendable methods: Evaporation & open burning. Not recommendable method: Landfill. Peer-review: Dilute with much air prior to evaporation. Care: Highly toxic gas, may be spontaneously flammable in air. (Peer-review conclusions of an IRPTC expert consultation (May 1985))

[United Nations. Treatment and Disposal Methods for Waste Chemicals (IRPTC File). Data Profile Series No. 5. Geneva, Switzerland: United Nations Environmental Programme, Dec. 1985., p. 231] \*\*PEER REVIEWED\*\*

Once used, VAPORPH3OS **Phosphine** Fumigant cylinders are to be returned only to an authorized distributor or their designated point of return. This applies to all cylinders, regardless of the quantity of material remaining in the cylinder. /VAPORPH3OS **Phosphine** Fumigant/

[EPA; Pesticide Product Label System (PPLS) - Search Results for VAPORPH3OS Phosphine Fumigant. Product Label Available from, as of April 23, 2007: <http://oaspub.epa.gov> \*\*PEER REVIEWED\*\*

## Occupational Exposure Standards:

### OSHA Standards:

Permissible Exposure Limit: Table Z-1 8-hr Time Weighted Avg: 0.3 ppm (0.4 mg/cu m).

[29 CFR 1910.1000; U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of August 30, 2006: <http://www.gpoaccess.gov/ecfr> \*\*PEER REVIEWED\*\*

Vacated 1989 OSHA PEL TWA 0.3 ppm (0.4 mg/cu m); STEL 1 ppm (1 mg/cu m) is still enforced in some states.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997., p. 370] \*\*PEER REVIEWED\*\*

### **Threshold Limit Values:**

8 hr Time Weighted Avg (TWA): 0.3 ppm; 15 min Short Term Exposure Limit (STEL): 1 ppm.

[American Conference of Governmental Industrial Hygienists TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH, 2008, p. 48] \*\*QC REVIEWED\*\*

### **NIOSH Recommendations:**

Recommended Exposure Limit: 10 Hr Time-Weighted Avg: 0.3 ppm (0.4 mg/cu m).

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

Recommended Exposure Limit: 15 Min Short-Term Exposure Limit: 1 ppm (1 mg/cu m).

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

### **Immediately Dangerous to Life or Health:**

50 ppm

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS

(NIOSH) Publication No. 2005-151 (2005)] \*\*PEER REVIEWED\*\*

## Other Standards Regulations and Guidelines:

AEGLs

### AEGLs for PHOSPHINE (ppm)

Exposure Time	AEGL 1 (Discomfort)	AEGL 2 (Impaired Escape)	AEGL 3 (Life Threatening/Death)
10 min	NR	4.0	7.2
30 min	NR	4.0	7.2
60 min	NR	2.0	3.6
4 hr	NR	0.50	0.90
8 hr	NR	0.25	0.45

[U.S. EPA; Acute Exposure Guideline Levels (AEGLs) - Results for Phosphine. Available from, as of July 31, 2009: <http://www.epa.gov/oppt/aegl/pubs/chemlist.htm> \*\*QC REVIEWED\*\*

West Germany: 0.1 ppm; USSR & Czechoslovakia: 0.07 ppm; Sweden 0.3 ppm.

[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986., p. 482] \*\*PEER REVIEWED\*\*

Emergency Response Planning Guidelines (ERPG): ERPG(1) Not appropriate; ERPG(2) 0.5 ppm (without serious, adverse effects) for up to 1 hr exposure; ERPG(3) 5 ppm (not life threatening) up to 1 hr exposure.

[American Industrial Hygiene Association. The AIHA 1999 Emergency Response Planning Guidelines and Workplace

Environmental Exposure Level Guides Handbook. American Industrial Hygiene Association. Fairfax, VA 1999., p. 26]

**\*\*PEER REVIEWED\*\***

## Manufacturing/Use Information:

### Uses:

For **phosphine** (USEPA/OPP Pesticide Code: 66500) ACTIVE products with label matches. /SRP: Registered for use in the U.S. but approved pesticide uses may change periodically and so federal, state and local authorities must be consulted for currently approved uses./

[National Pesticide Information Retrieval System's USEPA/OPP Chemical Ingredients Database on Phosphine (7803-51-2). Available from, as of November 1, 2006: <http://npirpublic.ceris.purdue.edu/ppis/> **\*\*PEER REVIEWED\*\***

Restricted use pesticide due to acute inhalation toxicity of highly toxic **phosphine** gas. ... VAPORPI130S **Phosphine** Fumigant is pure **phosphine** gas for use as a fumigant after on-site blending with forced air or with registered or food grade carbon dioxide for the production of non-flammable **phosphine** fumigant gas... /VAPORPH30S **Phosphine** Fumigant/

[EPA; Pesticide Product Label System (PPLS) - Search Results for VAPORPH30S Phosphine Fumigant. Product Label approved by EPA on December 27, 2005. Available from, as of April 23, 2007: <http://oaspub.epa.gov> **\*\*PEER REVIEWED\*\***

Restricted use pesticide due to acute inhalation toxicity of highly toxic **phosphine** gas... ECO2FUME Fumigant Gas is a **phosphine**-containing fumigant for use in controlling pests in listed raw agricultural commodities, processed foods, stored tobacco, animal feeds, and nonfood products. Not for use in barges. /ECO2FUME Fumigant/

[EPA; Pesticide Product Label System (PPLS) - Search Results for ECO2FUME Phosphine Fumigant. Product Label accepted by EPA on December 27, 2005. Available from, as of April 23, 2007: <http://oaspub.epa.gov> **\*\*PEER REVIEWED\*\***

INSECTICIDE USED FOR FUMIGATION OF ANIMAL FEED, LEAF STORED TOBACCO, BOX CARS, & USED FOR RODENT CONTROL.

[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982., p. 458] \*\*PEER REVIEWED\*\*

Organic preparations, phosphonium halides, doping agent for n-type semiconductors, polymerization initiator, condensation catalyst.

[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 14th Edition. John Wiley & Sons, Inc. New York, NY 2001., p. 869] \*\*PEER REVIEWED\*\*

As an intermediate for the preparation of several flame retardants.

[Toy ADF, Walsh EN; Phosphorus Chemistry in Everyday Living 2nd ed p.216 (1987)] \*\*PEER REVIEWED\*\*

... Use of **phosphine** in manufacture of photovoltaic cells ...

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1238] \*\*PEER REVIEWED\*\*

**Phosphine** is a food fumigant, used until now as an insecticide and rodenticide. The present work researches the action of **phosphine** treatment on growth and aflatoxin production of 23 Aspergillus strains. Production of aflatoxins B1, B2, G1, and G2 decreased in almost all cases by a ratio of 10 to 100. **Phosphine** treatment therefore seems favorable to prevent growth of various Aspergillus strains, in the context of keeping food safe.

[Leitao J, et al; Appl Environ Microbiol 53 (10): 2328-31 (1987)] \*\*PEER REVIEWED\*\* [PubMed Abstract Full text: PMC204108](#)

**Phosphine** is more toxic than methyl bromide; however, as less **phosphine** than methyl bromide is required to fumigate a given volume of grain, **phosphine** has proven to be safer.

[Hardman, J.G., L.E. Limbird, P.B., A.G. Gilman. Goodman and Gilman's The Pharmacological Basis of Therapeutics. 10th ed. New York, NY: McGraw-Hill, 2001., p. 1893] \*\*PEER REVIEWED\*\*

## Manufacturers:

Air Products and Chemicals, Inc., 720 Hamilton Blvd., Allentown, PA 18195-1501, (610) 481-6799; Industrial Gases Div., Specialty Gas Dept., R.D. 2, P.O. Box 351, Tamaqua, PA 18252, (570) 467-2981; Production sites: Catoosa, OK 74015; Morrisville, PA 19067

[SRI Consulting. 2006 Directory of Chemical Producers-United States. Menlo Park, CA. 2006, p. 797] \*\*PEER REVIEWED\*\*

Matheson Tri-Gas, Inc., 959 Route 46 East, Parsippany, NJ 07054, (973) 257-1100; Production site: Gloucester, MA 01930

[SRI Consulting. 2006 Directory of Chemical Producers-United States. Menlo Park, CA. 2006, p. 797] \*\*PEER REVIEWED\*\*

Cytec Industries, Inc., Five Garret Mountain Plaza, West Paterson, NJ 07424, 973/357-3372 /Registrant/

[National Pesticide Information Retrieval System's USEPA/OPP Chemical Ingredients Database on Phosphine (7803-51-2). Available from, as of Nov 9, 2006: <http://npirspublic.ceris.purdue.edu/ppis/> \*\*PEER REVIEWED\*\*

## Methods of Manufacturing:

Prepared from white phosphorus an aqueous alkali hydroxide; ... By treatment of  $\text{PH}_4\text{I}$  with KOH ... By pyrolysis of phosphorous acid ... By hydrolysis of metal phosphide such as calcium phosphide.

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. 13th Edition, Whitehouse Station, NJ: Merck and Co., Inc., 2001., p. 1315] \*\*PEER REVIEWED\*\*

By action of freshly formed hydrogen or of caustic potash on phosphorus.

[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 14th Edition. John Wiley & Sons, Inc. New York, NY 2001., p. 869] \*\*PEER REVIEWED\*\*

By reaction of certain metal phosphides with water; hydrolysis of phosphorus in a base such as sodium hydroxide or calcium hydroxide,  $\text{Ca}(\text{OH})_2$  (hydrated lime); and reduction of red phosphorus in hot phosphoric acid solution.

[Toy ADF, Walsh EN; Phosphorus Chemistry in Everyday Living 2nd ed p.140 (1987)] \*\*PEER REVIEWED\*\*

... Common industrial methods are based on disproportionation reactions of elemental phosphorus catalyzed by alkalies or acids.

[Ullmann's Encyclopedia of Industrial Chemistry. 6th ed.Vol 1: Federal Republic of Germany: Wiley-VCH Verlag GmbH & Co. 2003 to Present, p. V26 206 (2003)] \*\*PEER REVIEWED\*\*

... Generated from aluminum phosphide and ammonium carbamate in the presence of moisture.

[Ullmann's Encyclopedia of Industrial Chemistry. 6th ed.Vol 1: Federal Republic of Germany: Wiley-VCH Verlag GmbH & Co. 2003 to Present, p. V18 203 (2003)] \*\*PEER REVIEWED\*\*

## General Manufacturing Information:

US PATENTS 2,117,158; 2,826,486; 2,826,527; 3,132,067. BRITISH PATENTS 729,380; 893,711. USSR PATENT 308,556. GERMAN PATENT 1,122,762 & OTHERS. INTRODUCED AS GRAIN FUMIGANT IN 1935 BY CHEMICAL FABRIK DELITIA, GERMANY, BY MEANS OF BAG METHOD. GERMAN PATENT 667,257; 698,721 & OTHERS. IMPROVED METHOD (TABLETS) DEVELOPED BY DEGESCH IN 1953 & IMPROVED AGAIN (PELLETS) IN 1960.

[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982., p. 458] \*\*PEER REVIEWED\*\*

Acetylene prepared from calcium carbide occasionally contains **phosphine**.

[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Manual Two. Washington, DC: U.S. Government Printing Office, Oct., 1978., p. 3211] \*\*PEER REVIEWED\*\*

FOR FUMIGATION PURPOSES ... GENERATED BY REACTION OF ALUMINUM PHOSPHIDE WITH WATER VAPOR IN SURROUNDING AIR.

[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute,

Agriculture Canada, Ottawa, Canada: Information Canada, 1982., p. 458] \*\*PEER REVIEWED\*\*

A synthetic dye, crysaniline yellow, is sometimes called **phosphine**.

[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 14th Edition. John Wiley & Sons, Inc. New York, NY 2001., p. 869] \*\*PEER REVIEWED\*\*

The commercial product is a tablet of aluminum phosphide and ammonium carbamate impregnated with paraffin. Upon reaction with water or atmospheric moisture, **phosphine** is released. The ammonium carbamate decomposes to carbon dioxide and ammonia, and these gases prevent the **phosphine** generated from igniting spontaneously.

[Toy ADF, Walsh EN; Phosphorus Chemistry in Everyday Living 2nd ed p.216 (1987)] \*\*PEER REVIEWED\*\*

...It may be generated from aluminum or zinc phosphide and water for grain fumigation. It may be present in phosphorus as a polymer or generated at low rates under alkaline conditions and at a temperature of 85 deg C. The generation of acetylene from calcium carbide containing calcium phosphide as an impurity and metal processing procedures in which phosphides are formed are the most frequent sources of industrial hygiene problems with **phosphine**.

[Bingham, E.; Cohrssen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. 3:471] \*\*PEER REVIEWED\*\*

**Phosphine** gas is used indoors to control a broad spectrum of insects for non-food/non-feed commodities in sealed containers or structures. There are no homeowner or agricultural row crop uses for this product.

[USEPA/Office of Pesticide Programs; Pesticide Fact Sheet for Phosphine (December 1999). Available from, as of November 7, 2006: <http://www.epa.gov/opprd001/factsheets/> \*\*PEER REVIEWED\*\*

## Formulations/Preparations:

DETIA **GAS-EX-B**--CONTAINING 57% ALUMINUM PHOSPHIDE & UP TO 20% ALUMINUM STEARATE. EACH BAG DEVELOPS 11 G PURE **HYDROGEN PHOSPHIDE**. ... PHOSTOXIN TABLETS & PELLETS ... 1 TABLET RELEASES 1 G **PHOSPHINE**; 1 PELLETT RELEASES 0.2 G **PHOSPHINE** BOTH DISINTEGRATE WITHIN 48-72



HR, LEAVING RESIDUE OF MAINLY ALUMINUM OXIDE HYDRATE WITH 1% ALUMINUM PHOSPHIDE.

[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982., p. 458] \*\*PEER REVIEWED\*\*

Electronic grade: 99.995% and 99.999%.

[Kuney, J.H. and J.N. Nullican (eds.) Chemcyclopedia. Washington, DC: American Chemical Society, 1988., p. 228]

\*\*PEER REVIEWED\*\*

VAPORPH3OS Active Ingredient 99.3% **Phosphine**

[National Pesticide Information Retrieval System's USEPA/OPP Chemical Ingredients Database on Phosphine (7803-51-2). Available from, as of November 1, 2006: <http://npirspublic.ceris.purdue.edu/ppis/> \*\*PEER REVIEWED\*\*

ECO2FUME Active Ingredient: 98% Dry ice, 2% **Phosphine**

[National Pesticide Information Retrieval System's USEPA/OPP Chemical Ingredients Database on Phosphine (7803-51-2). Available from, as of November 1, 2006: <http://npirspublic.ceris.purdue.edu/ppis/> \*\*PEER REVIEWED\*\*

## Impurities:

The presence of traces (0.2%) of diphosphane in **phosphine** as normally prepared ...

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1237] \*\*PEER REVIEWED\*\*

## Laboratory Methods:

### Clinical Laboratory Methods:

**Phosphine** was analyzed in postmortem specimens of a man by headspace gas chromatography using nitrogen

phosphorus detector.

[Chan LT et al; J Anal Toxicol 7 (4): 165-7 (1983)] \*\*PEER REVIEWED\*\* [PubMed Abstract](#)

## Analytic Laboratory Methods:

DETERMINATION IN AIR BY GC.

[DUMAS T; J ASSOC OFF ANAL CHEM 61 (1): 5-7 (1978)] \*\*PEER REVIEWED\*\*

COMPARISON OF GAS CHROMATOGRAPHY, CHROMOGENIC, COLORIMETRIC, ELECTROCHEMICAL & SAMPLING TECHNIQUES IS REVIEWED.

[VERSTUYFT AW; AM IND HYG ASSOC J 29 (6): 431-437 (1978)] \*\*PEER REVIEWED\*\*

MATRIX: AIR; PROCEDURE: COLORIMETRY; RANGE: 0.195-0.877 MG/CU M.

[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing Office, 1977-present., p. V5 S332-1] \*\*PEER REVIEWED\*\*

Airborne concentrations of **phosphine** can be collected in a fitted-glass bubbler containing silver diethyldithiocarbamate. A complex is formed and analyzed spectrographically. Gas chromatography using a flame photometric (phosphorus mode) detector is applicable.

[Bingham, E.; Cohrssen, B.; Powell, C.H.; Patty's Toxicology Volumes 1-9 5th ed. John Wiley & Sons. New York, N.Y. (2001)., p. 3:471] \*\*PEER REVIEWED\*\*

Chemically impregnated paper tapes can be used for the determination of toxic gases in air.

[Brandon RW; Anal Chem Symp Ser 17 (Chem Sens): 726-31 (1983)] \*\*PEER REVIEWED\*\*

Portable gas chromatography for determination of **phosphine** in air.

[Bond EJ, Dumas T; J Agric Food Chem 30 (5): 986-8 (1982)] \*\*PEER REVIEWED\*\*

Results reveal some of the limitations in using detector tubes for measuring **phosphine** concn either in fumigation or for monitoring **phosphine** in air near fumigated material.

[Leesch JG; J Econ Entomol 75 (5): 899-905 (1982)] \*\*PEER REVIEWED\*\*

**Phosphine** was determined quantitatively by inductively coupled plasma-atomic emission spectrometry (ICP-AES) and results compared with those by a colorimetric method. Potassium orthophosphate was used as artificial sample to provide a source of **phosphine**. The limits of detection of both methods were about the same but the inductively coupled plasma-atomic emission spectrometry method was less tedious and less time consuming.

[Mortensen G et al; Anal Lett 22 (7): 1791-806 (1989)] \*\*PEER REVIEWED\*\*

Method: OSHA 1003; Procedure: inductively coupled plasma-atomic emission spectroscopy; Analyte: **phosphine**; Matrix: air; Detection Limit: 32 ppb (45 ug/cu m).

[U.S. Department of Labor/Occupational Safety and Health Administration's Index of Sampling and Analytical Methods. Available from: <http://www.osha.gov/dts/sltc/methods/toc.html> on Phosphine (7803-51-2) as of November 3, 2006] \*\*PEER REVIEWED\*\*

Method: NIOSH 6002, Issue 2; Procedure: uv-vis spectrometer; Analyte: **phosphine**; Matrix: air; Detection Limit: 0.1 ug per sample.

[CDC; NIOSH Manual of Analytical Methods, 4th ed. Phosphine (7803-51-2). Available from, as of November 3, 2006: <http://www.cdc.gov/niosh/docs/2003-154/> \*\*PEER REVIEWED\*\*

Method: OSHA ID-180; Procedure: ion chromatography; Analyte: **phosphine**; Matrix: air; Detection Limit: 0.015 ppm per 36-L air sample.

[U.S. Department of Labor/Occupational Safety and Health Administration's Index of Sampling and Analytical Methods. Available from: <http://www.osha.gov/dts/sltc/methods/toc.html> on Phosphine (7803-51-2) as of November 3, 2006] \*\*PEER REVIEWED\*\*

**Phosphine** present during fumigation can be determined using commercially available detector tubes, by glc ... or by aspiration through aqueous mercuric chloride and measuring the change in electrical conductivity.

[Tomlin CDS, ed. Phosphine (7803-51-2). In: The e-Pesticide Manual, 13th Edition Version 3.2 (2005-06). Surrey UK, British Crop Protection Council.] \*\*PEER REVIEWED\*\*

## Sampling Procedures:

NIOSH Method S332. Analyte: **Phosphine**. Matrix: Air. Procedure: Collection on coated silica gel, Permanganate, extraction. Flow Rate: 0.2 to 0.01 l/min. Sample size: 16 liters.

[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing Office, 1977-present., p. S332-1] \*\*PEER REVIEWED\*\*

## Special References:

## Special Reports:

WHO; Environ Health Criteria: **Phosphine** and Selected Metal Phosphides (1988). Review of the properties, analysis, and occurrence of **phosphine** including effects on organisms in the environment, animals, and man, and evaluated the hazard faced by those exposed to **phosphine**.

## History and Incidents:

Two children and 29 of 31 crew members aboard a grain freighter became acutely ill after inhaling the toxic fumigant **phosphine**. One child died. Predominant symptoms were headache, fatigue, nausea, vomiting, cough and shortness of breath. Abnormal physical findings included jaundice, anesthetics, ataxia, intention tremor and diplopia. Focal myocardial infiltration with necrosis, pulmonary edema, and widespread small-vessel injury were found at postmortem exam of the dead child. The surviving child showed electrocardiogram and echocardiographic evidence of myocardial

injury and transient elevation of the MB fraction of serum creatinine phosphokinase.

[Wilson R et al; J Am Med Assoc 244 (2): 148-50 (1980)] \*\*PEER REVIEWED\*\*

## Synonyms and Identifiers:

### Related HSDB Records:

6035 [ALUMINUM PHOSPHIDE] (Parent)

963 [CALCIUM PHOSPHIDE] (Parent)

1059 [ZINC PHOSPHIDE] (Parent)

### Synonyms:

AL PHOS

\*\*PEER REVIEWED\*\*

CELPHOS

\*\*PEER REVIEWED\*\*

DELICIA

\*\*PEER REVIEWED\*\*

DETIA

\*\*PEER REVIEWED\*\*

DETIA **GAS EX-B**

**\*\*PEER REVIEWED\*\***

FOSFOROWODOR (POLISH)

**\*\*PEER REVIEWED\*\***

FUMI STRIP

**\*\*PEER REVIEWED\*\***

**GAS-EX-B**

**\*\*PEER REVIEWED\*\***

**HYDROGEN PHOSPHIDE**

**\*\*PEER REVIEWED\*\***

MAGTOXIN

**\*\*PEER REVIEWED\*\***

PHOSPHORATED HYDROGEN

**\*\*PEER REVIEWED\*\***

PHOSPHORETTED HYDROGEN

**\*\*PEER REVIEWED\*\***

PHOSPHOROUS HYDRIDE

**\*\*PEER REVIEWED\*\***

PHOSPHORUS HYDRIDE

**\*\*PEER REVIEWED\*\***

## PHOSPHORUS TRIHYDRIDE

**\*\*PEER REVIEWED\*\***

## PHOSPHORWASSERSTOFF (GERMAN)

**\*\*PEER REVIEWED\*\***

## POLYTANOL

**\*\*PEER REVIEWED\*\***

USEPA/OPP Pesticide Code: 66500

**\*\*PEER REVIEWED\*\***

## Associated Chemicals:

Di-, mono-, triphosphine;13445-50-6

## Formulations/Preparations:

DETIA **GAS-EX-B**--CONTAINING 57% ALUMINUM PHOSPHIDE & UP TO 20% ALUMINUM STEARATE. EACH BAG DEVELOPS 11 G PURE **HYDROGEN PHOSPHIDE**. ... PHOSTOXIN TABLETS & PELLETS ... 1 TABLET RELEASES 1 G **PHOSPHINE**; 1 PELLETT RELEASES 0.2 G **PHOSPHINE** BOTH DISINTEGRATE WITHIN 48-72 HR, LEAVING RESIDUE OF MAINLY ALUMINUM OXIDE HYDRATE WITH 1% ALUMINUM PHOSPHIDE.

[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982., p. 458] **\*\*PEER REVIEWED\*\***

Electronic grade: 99.995% and 99.999%.

[Kuney, J.H. and J.N. Nullican (eds.) Chemcyclopedia. Washington, DC: American Chemical Society, 1988., p. 228]

**\*\*PEER REVIEWED\*\***

VAPORPH3OS Active Ingredient 99.3% **Phosphine**

[National Pesticide Information Retrieval System's USEPA/OPP Chemical Ingredients Database on Phosphine (7803-51-2). Available from, as of November 1, 2006: <http://npirpublic.ceris.purdue.edu/ppis/> \*\*PEER REVIEWED\*\*

ECO2FUME Active Ingredient: 98% Dry ice, 2% **Phosphine**

[National Pesticide Information Retrieval System's USEPA/OPP Chemical Ingredients Database on Phosphine (7803-51-2). Available from, as of November 1, 2006: <http://npirpublic.ceris.purdue.edu/ppis/> \*\*PEER REVIEWED\*\*

### Shipping Name/ Number DOT/UN/NA/IMO:

UN 2199; **PHOSPHINE**

IMO 2.0; **Phosphine**

### Standard Transportation Number:

49 201 60; **Phosphine**

### EPA Hazardous Waste Number:

P096; An acute hazardous waste when a discarded commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate.

### Administrative Information:



**Hazardous Substances Databank Number:**

1233

**Last Revision Date:**

20070604

**Last Review Date:**

Reviewed by SRP on 1/11/2007

**Update History:**

Field Update on 2014-12-05, 2 fields added/edited/deleted  
Field Update on 2010-09-07, 1 fields added/edited/deleted  
Field Update on 2010-04-27, 1 fields added/edited/deleted  
Field Update on 2009-09-04, 1 fields added/edited/deleted  
Field Update on 2009-04-16, 2 fields added/edited/deleted  
Field Update on 2008-08-23, 1 fields added/edited/deleted  
Field Update on 2008-08-22, 1 fields added/edited/deleted  
Field Update on 2008-08-21, 1 fields added/edited/deleted  
Complete Update on 2007-06-04, 66 fields added/edited/deleted  
Field Update on 2006-04-18, 2 fields added/edited/deleted  
Field Update on 2006-04-17, 2 fields added/edited/deleted  
Complete Update on 2005-06-24, 2 fields added/edited/deleted  
Field Update on 2005-01-27, 2 fields added/edited/deleted  
Complete Update on 02/14/2003, 1 field added/edited/deleted.  
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Complete Update on 10/14/1986  
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